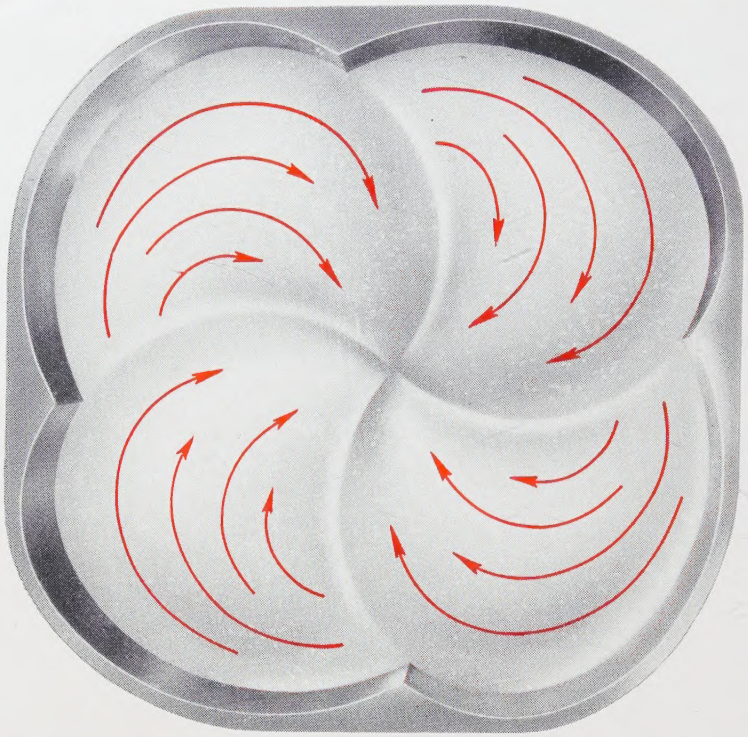
Tappi

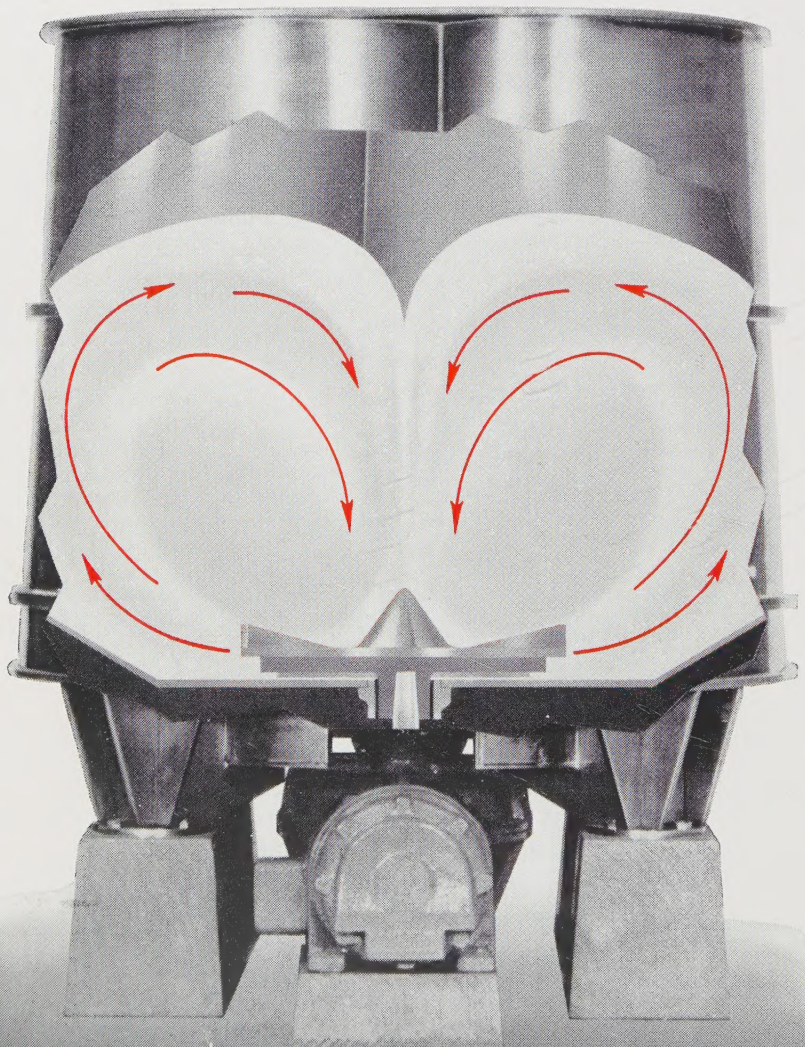
THE JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

MAY 1961

VOLUME 44 • NUMBER 5

8 BIG REASONS why mills choose th EMERSON TRIPLE ATTACK PULPE





1 FAST, UNIFORM DEFIBERING
Triple Attack pulping results from the (violent action of the impellor, which (2) forc stock against the lobe-shaped, tapered tub wa which redirects it (3) against more onrushi stock coming from the impellor. No dead spc exist as fibers go through repeated cycles of cc tact with the impellor, tub wall and other fibe

2 BOTTOM ROTOR
A heavy steel weldment body with 6 repla able cast segments, each having a stainle steel vane, hard faced for wear resistance. Assur immediate pulp submergence and complete, u form defibering, mixing or blending of full or p tial charges.

3 BATCH OR CONTINUOUS PULPING
Batch pulping at 3% to 12% consisten Continuous pulping at 2% to 5% consisten is accomplished by changing the extraction pla and adding a regulating box.

4 LOW POWER CONSUMPTION
HP is conserved by high consistency pulpi — not wasted in circulating excess wat

5 FAST, CLEAN DUMPING
Short, direct connection is made between t sloped extraction chamber and outlet va and pump. Simplifies piping installation. Extr tion plate area speeds dumping and prevents f eign material from reaching pump and val

6 ENGINEERED FOR SERVICE
Unitized construction enables shipping ent unit in 1, 2 or 3 sections, match-marked easy field erection. No joint leading necessa Rugged, high alloy stainless or tile construct resists acids and chemicals in deinking or strength defibering. Five water jets in bottom s tion do thorough job of cleansing when necess to change colors.

7 WET STRENGTH DEFIBERING
Triple Attack action breaks down wet stren furnishes in 40 to 45 minutes. Water tempe ture is easily raised by admitting live steam the direction of stock flow through a tangen inlet at each of the 4 lobes of the tub.

8 PULPING VERSATILITY
Defibers, mixes or blends virgin pu bleached or unbleached sulphite, soda, Kr groundwood, news, waste papers, old corrugat shoe board, milk cartons and all types of strength papers.

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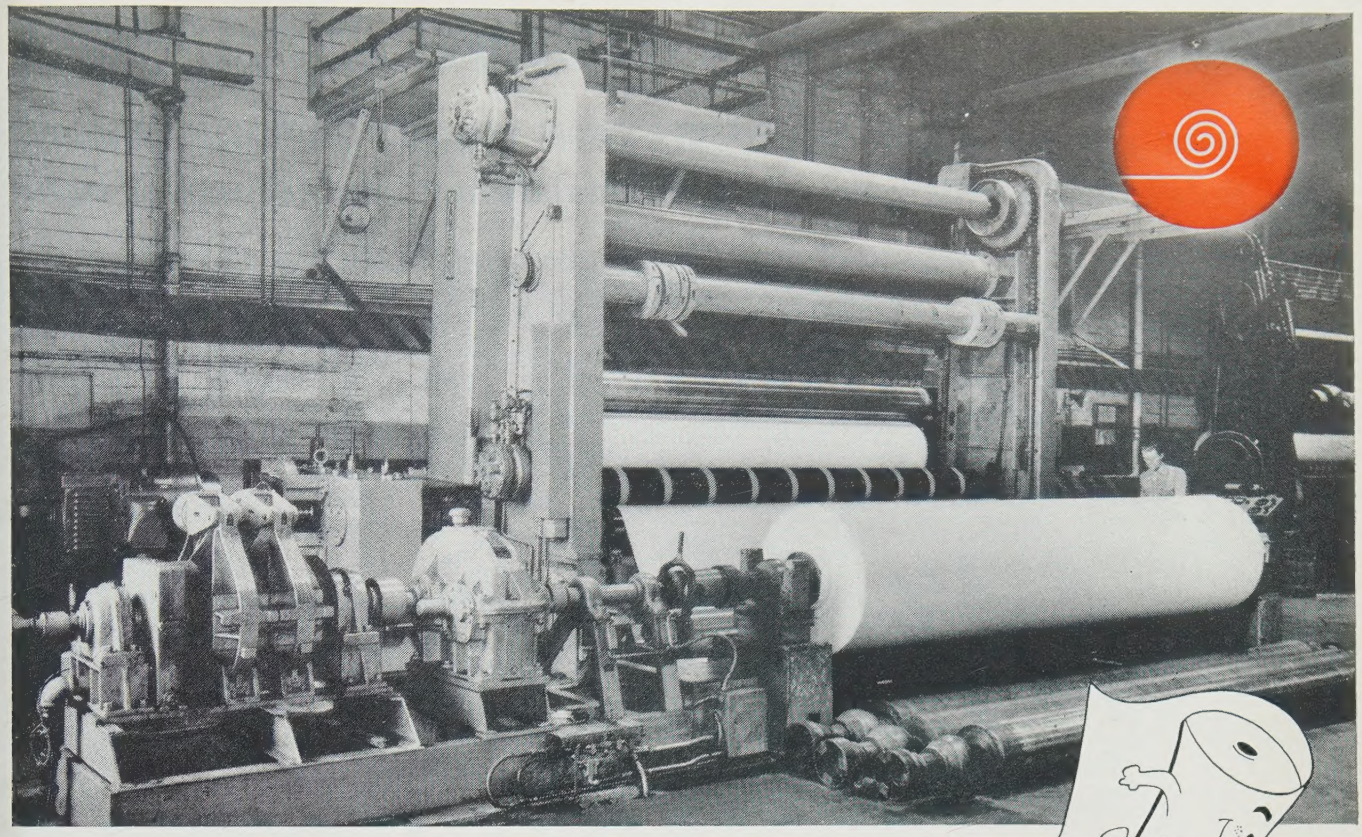

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...external main drive gear box and flexible couplings isolate vibration and deflection which might otherwise cause imperfections in rewinding rolls.

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AA-393

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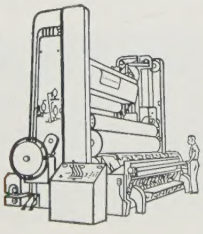

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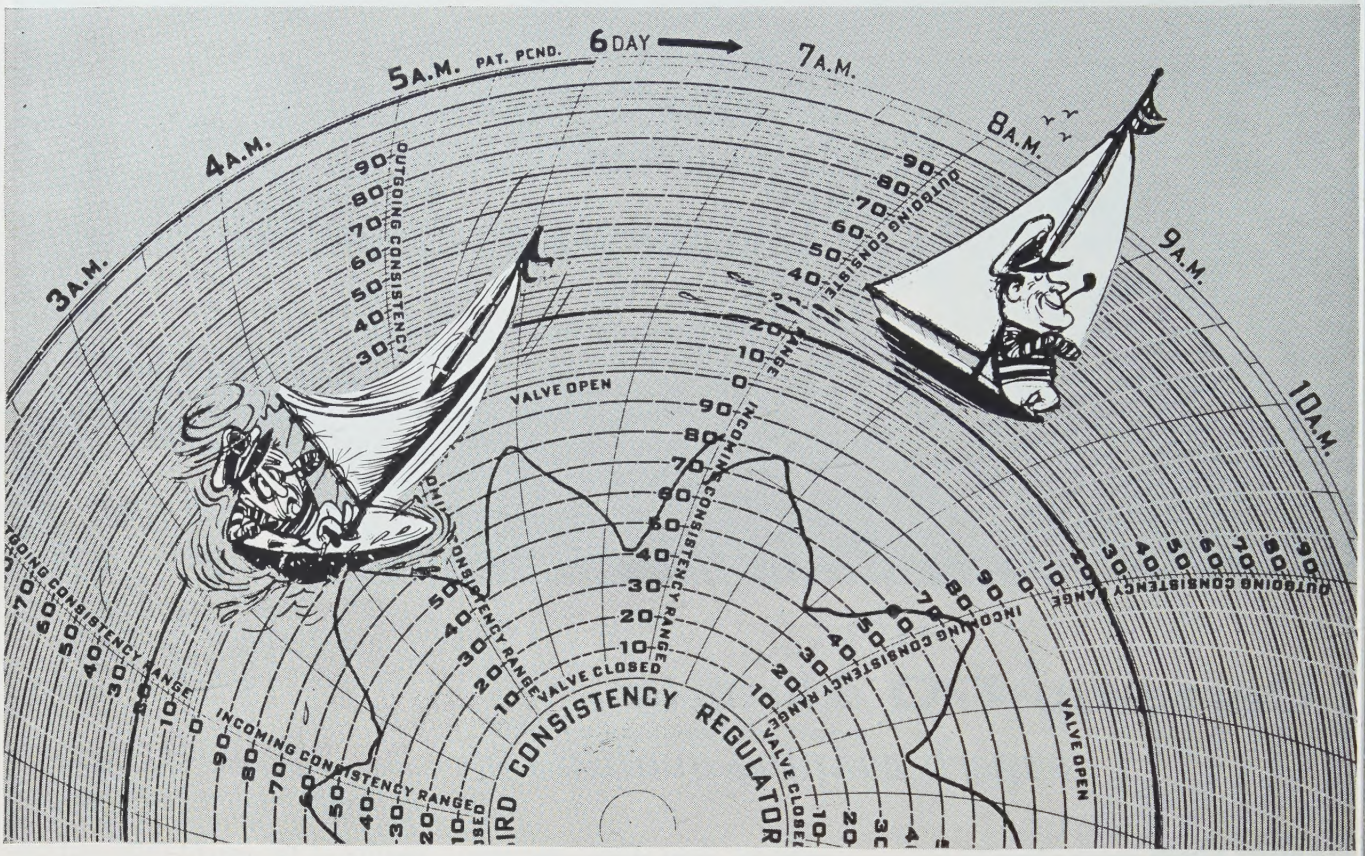

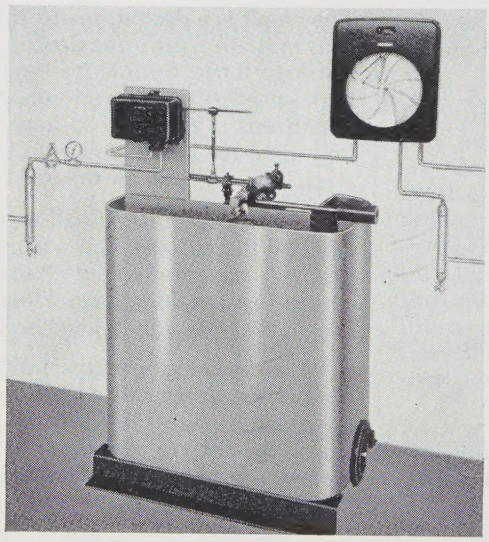

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Tenth Statistics Course
Queens Univ., Kingston, Ontario
June 19–30, 1961

Lignin Symposium
Edgewater Beach Hotel, Chicago, Ill.
Aug. 14–16, 1961

Twelfth Testing Conference
Queen Elizabeth Hotel, Montreal, Que.
Aug. 15–18, 1961

Eleventh Corrugated Containers Conference
St. Francis Hotel, San Francisco, Calif.
Sept. 6–8, 1961

Fourth International Mechanical Pulping Conference
(Tech. Sect., CPPA-TAPPI)
Edgewater Beach Hotel, Chicago, Ill.
Sept. 19–21, 1961

Sixth Deinking Conference
Hotel Harris, Kalamazoo, Mich.
Oct. 4–6, 1961

Sixteenth Plastics-Paper Conference
French Lick Sheraton Hotel,
French Lick, Ind.
Oct. 9–11, 1961

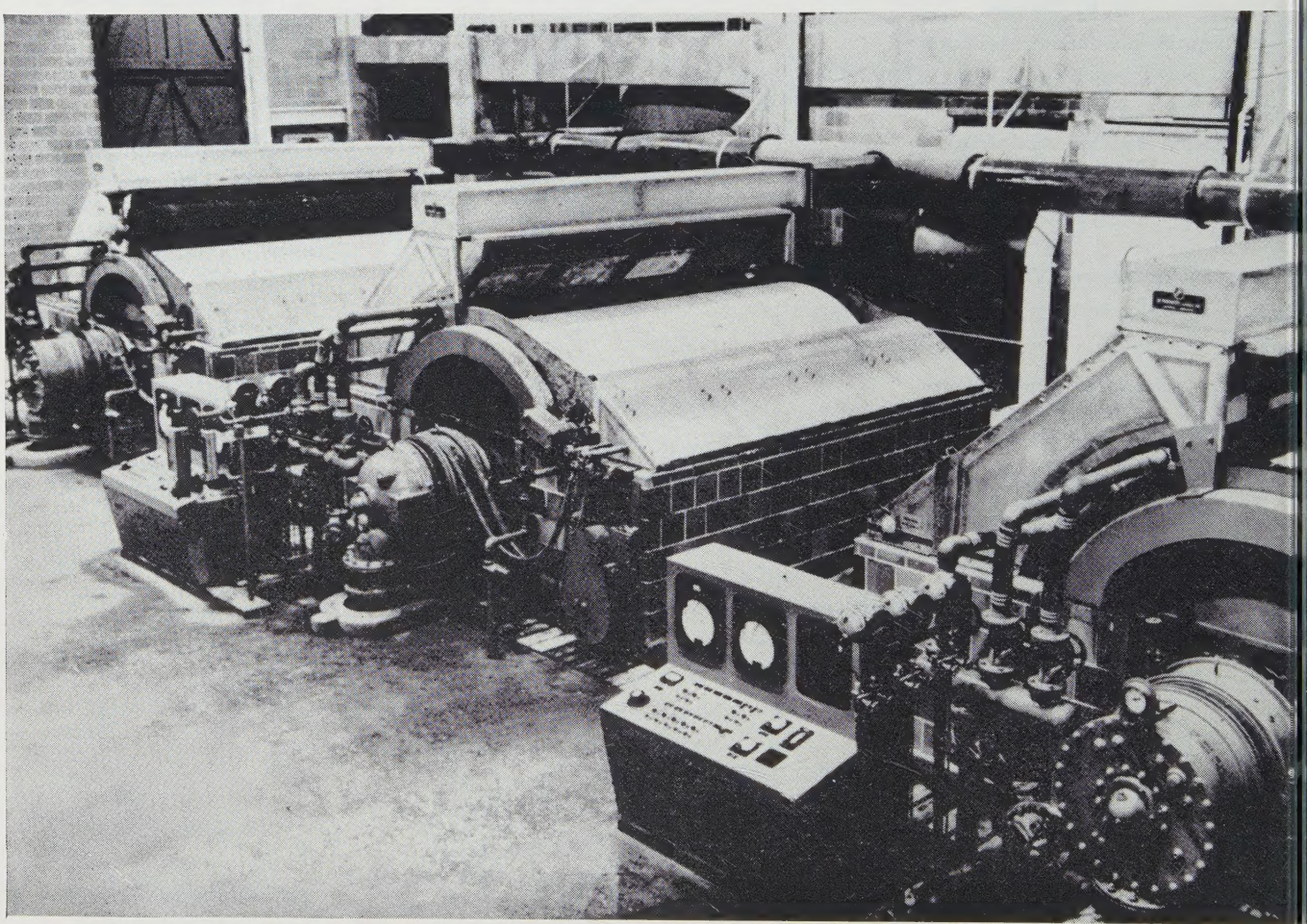
Sixteenth Engineering Conference
Shoreham Hotel, Washington, D. C.
Oct. 15–19, 1961

Fifteenth Alkaline Pulping Conference
Rice Hotel, Houston, Tex.
Nov. 1–3, 1961

Please refer to Local Section Activities for the locations and dates of Section Meetings

Complete Dorr-Oliver Continuous BLEACHING SYSTEM

installed at
St. Lawrence Corporation, Limited

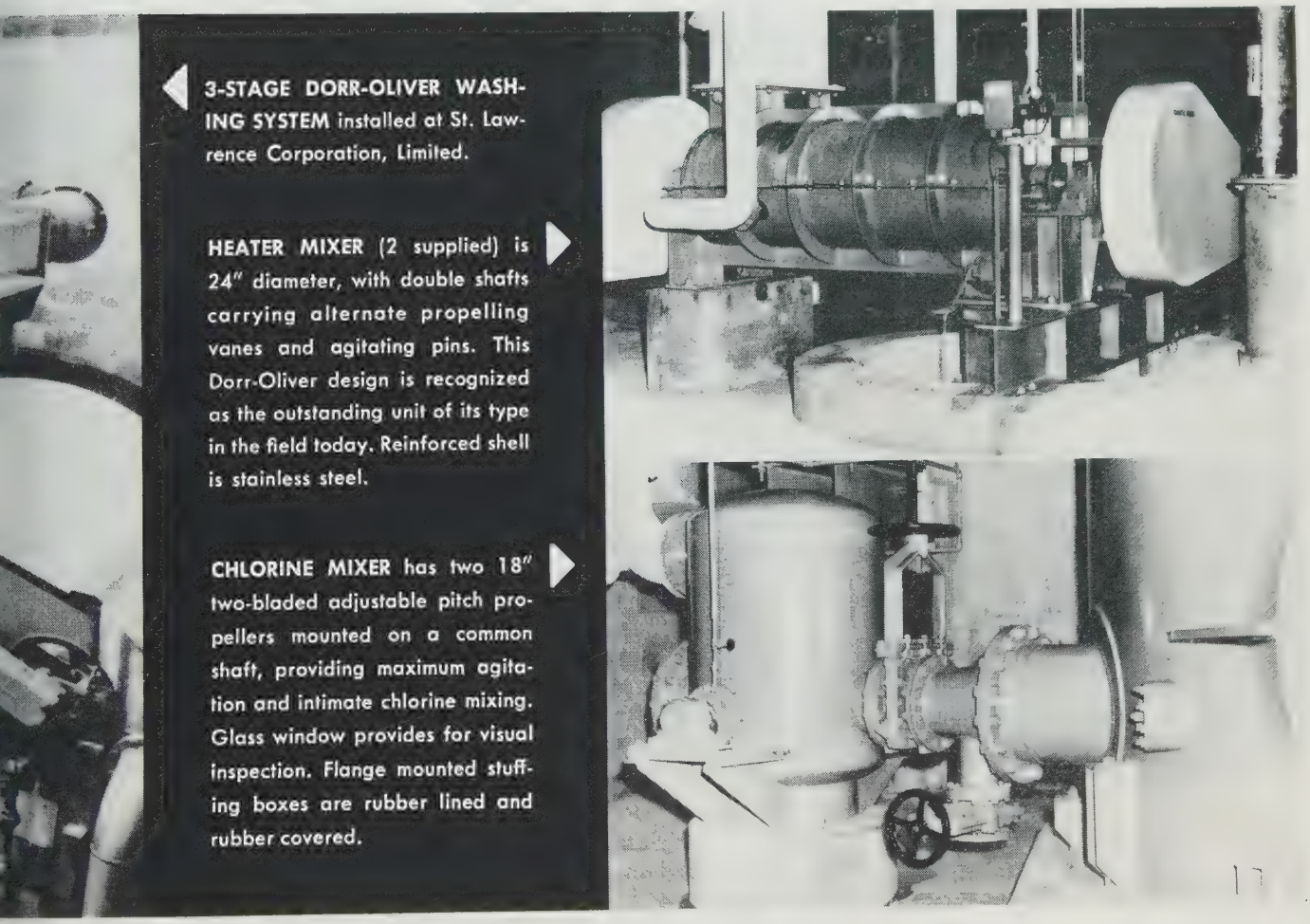


WHEN the old-established St. Lawrence Corporation, Limited decided to add a bleach plant to its newsprint and kraft liner board mill at Red Rock, Ontario, extensive investigation resulted in the choice of a Dorr-Oliver Continuous 3-Stage Bleaching System. Advantage was taken of the local engineering and manufacturing services of Dorr-Oliver's associated Canadian company, Dorr-Oliver-Long Limited, which supplied all equipment.

The washing system comprises three 8′ dia. x 12′ face washers, designed for an ultimate capacity of 200 tons per day. The first is a rubber covered chlorination washer, which includes a press roll. The second stage is the caustic extraction washer, constructed of stainless steel for possible future chlorine dioxide service. The third and final stage is a rubber covered hypochlorite washer. All washers have double roll dischargers and are in tile vats with fibreglass hoods.

For complete coordination of all phases of the bleaching operation, choice was also made of a Dorr-Oliver rubber lined chlorine mixer, two heater mixers and circulators for the caustic and hypo towers.

This installation is another example of the world-wide engineering and equipment service offered by Dorr-Oliver to the pulp and paper industry. Complete systems or individual equipment units can be supplied for bleach washing, brownstock washing, deckering and thickening, screening, recausticizing, sheet and board forming, fibre recovery, waste treatment and SO_2 production. For information, write Dorr-Oliver Incorporated, Stamford, Connecticut.



3-STAGE DORR-OLIVER WASHING SYSTEM installed at St. Lawrence Corporation, Limited.

HEATER MIXER (2 supplied) is 24" diameter, with double shafts carrying alternate propelling vanes and agitating pins. This Dorr-Oliver design is recognized as the outstanding unit of its type in the field today. Reinforced shell is stainless steel.

CHLORINE MIXER has two 18" two-bladed adjustable pitch propellers mounted on a common shaft, providing maximum agitation and intimate chlorine mixing. Glass window provides for visual inspection. Flange mounted stuffing boxes are rubber lined and rubber covered.

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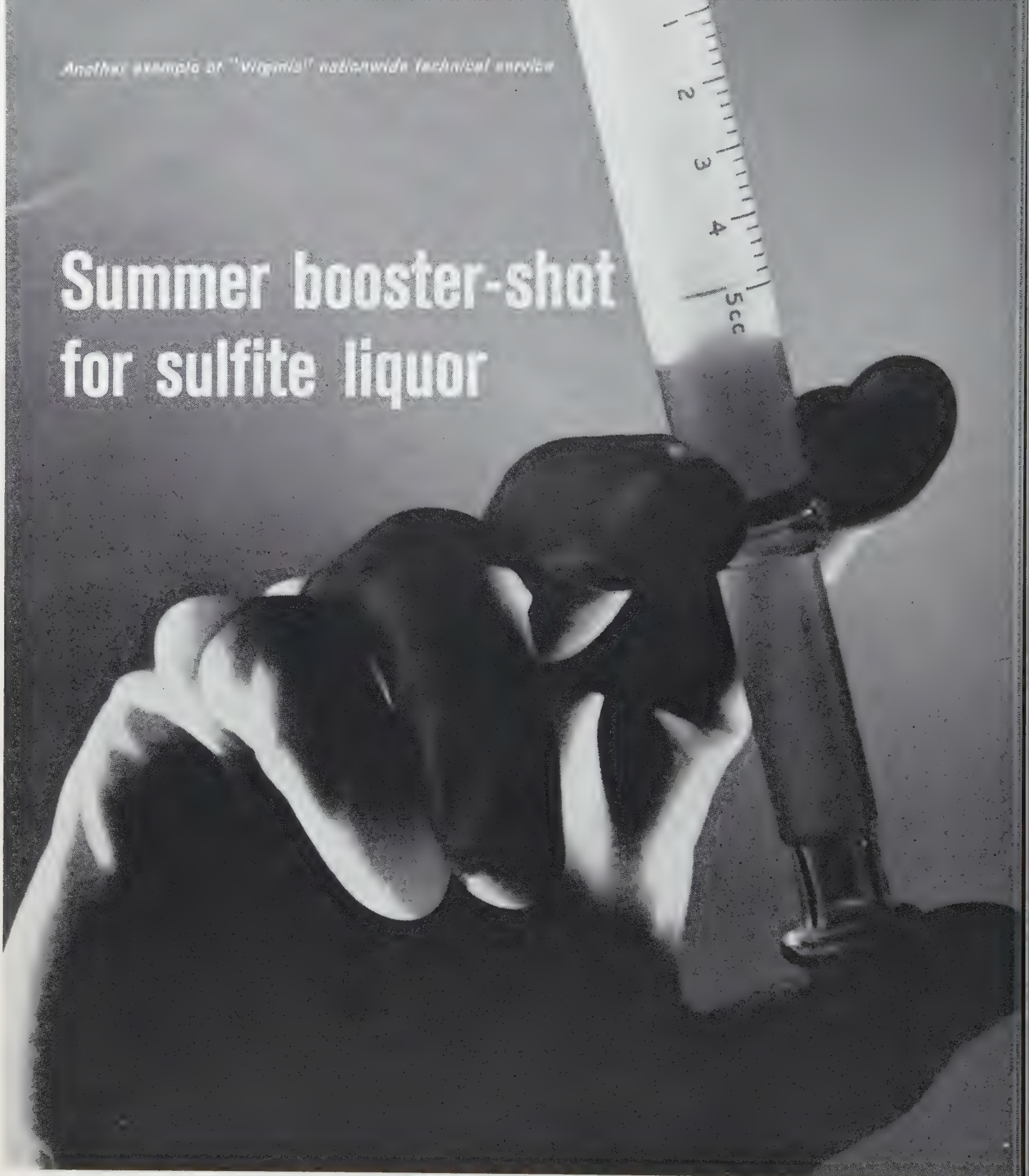
Another example of "Virginia" nationwide technical service

Summer booster-shot for sulfite liquor



A pulp mill was plagued year after year by an efficiency loss of about 30% in the sulfite acid-making plant caused by summer-warmed water. As a result, both pulping capacity and pulp quality dropped off. The mill people decided to try refortifying their sulfite cooking acid and ordered a tank car of Virginia SO_2 (99.9% pure). We sent a technical service man along. He found best results were obtained by adding liquid SO_2 to the sulfite acid storage tank through an open stainless steel pipe. Strength of the cooking acid was quickly raised to the required 6.5% level. Pleased with the results of this summer-time emergency treatment, the mill took a hard look at year-round variations in acid strength and pulp quality—now plans a permanent installation that will permit efficient use of liquid SO_2 as needed throughout the year. This will assure constant-strength sulfite liquor, a higher yield from the digesters, and a better end product. If your sulfite liquor needs a summer booster shot, write us for d
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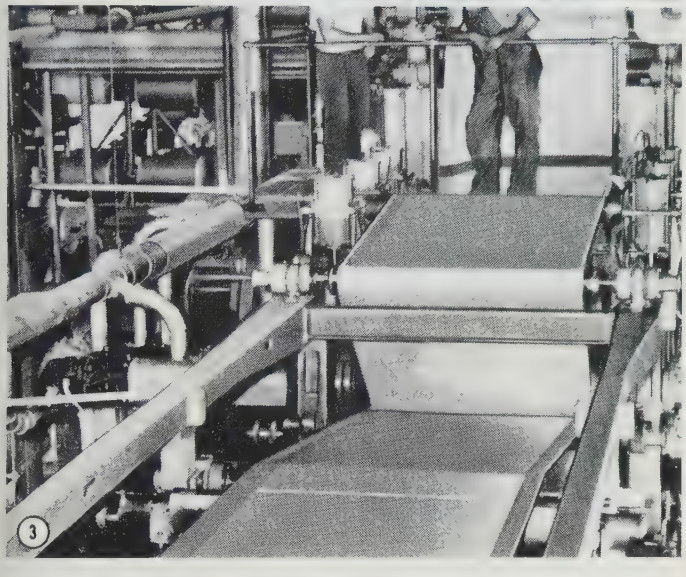

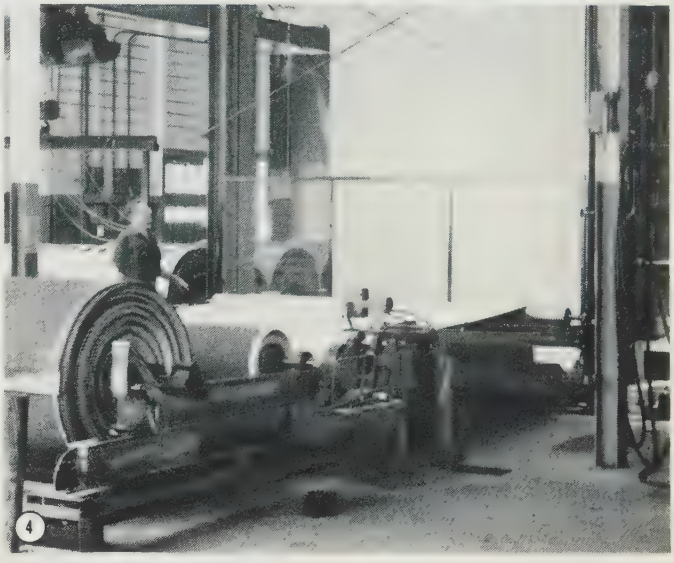

They're getting profit ideas on paper with Goodyear latices

Big news-makers in the paper industry are the special products being developed to do special jobs. Like making a stronger, more oil-resistant gasket. (1) Or toughening up tape. (2) Or making dielectric sheets more solvent-resistant. (3) Or printing full-color flooring patterns 100 times sharper. (4) And to do these jobs, paper manufacturers are turning to Goodyear latices.

Want to give your paper improved body, drape, strength and dimensional stability—greater flexibility and softness—outstanding resistance to wear and aging? Then Goodyear latex is the answer.

To simplify selecting them, Goodyear offers four basic types: PLIOLITE *Latex* in two forms (as a rubber or resin dispersion), PLIOVIC *Latex* (dispersion of vinyl copolymer resin), and CHEMIGUM *Latex* (dispersion of nitrile rubber). Each can be used alone—in combination with another—or as a modifier in your present materials. For the finest in technical help on latices, including the latest *Tech Book Bulletins,* write Goodyear, Chemical Division, Dept. E-9432, Akron 16, Ohio.

PLIOLITE
PLIOVIC
CHEMIGUM

Lots of good things come from

GOODYEAR

CHEMICAL DIVISION

Chemigum, Pliolite, Pliovic—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

MANUAL FOR TAPPI LOCAL SECTIONS

This manual has been prepared to acquaint TAPPI local sections and districts with those policies and operating practices which should enable them to operate effectively in the attainment of TAPPI's objects. Obviously all sections may not wish to operate in an identical manner, since each group has its own particular interests. Nevertheless, this manual should provide the base upon which each section can build an organization and program to suit its individual needs.

CHAPTER I—OBJECTS AND POLICIES OF THE ASSOCIATION

Article XII of TAPPI's Constitution makes provision for the establishment of local sections to carry out more effectively the aims of the association. The policy of the association's executive committee with regard to local sections is to encourage their formation, foster their growth, and provide support of their activities. This policy recognizes the need for local autonomy, which will be upheld so long as the objects of the local sections are consistent with those of the parent organization.

These objects as stated in Article II of the Constitution are:

a. To further the application of the sciences in the pulp and paper industry.

b. To promote investigation, research, and interchange of ideas among its members in the field of pulp and paper manufacture and use.

c. To promote education in the science and practice of pulp and paper manufacture.

d. To arrange for the collection and dissemination of information relating to the pulp and paper industry and for the presentation, discussion, and publication of papers and other contributions.

e. To provide technical facts, data, and standards fundamental to pulp and paper manufacture and use.

f. To promote the professional, social, and economic welfare of its members.

A local section is a regional group which has been chartered by the association to foster these objects at the local level. The local section consists of individuals who may or may not belong to the association.

The section may be subdivided into districts to reduce the travel distances involved and thus increase the number of participants and their activity. The section provides a local forum for the industry's technical men in a given area, and as such its technical programs should reflect the prevailing interests of its members. In this way the local section is uniquely qualified to undertake many programs which could not be effectively implemented on a national scale by the association.

CHAPTER II—ORGANIZATION OF THE ASSOCIATION

Before considering local section operations, it may be helpful to outline the basic structure of the association and its relationship to the local sections. The following is a brief description of the functions of key officers and committees responsible for local section activities.

Executive Committee

The executive committee is the governing body of the association. It consists of the president, the vice-president, and 12 members, four of whom are elected each year by the voting members of the association for 3-year terms. Its duties and responsibilities are defined in the constitution and bylaws of the association and include determining policy and having general charge of the affairs of the association.

President and Vice-President

The president and vice-president are the two officers of the association elected by the voting members to one-year terms of office. Their duties and responsibilities are defined in the constitution and bylaws of the association. The president presides at all meetings of the association and serves as chairman of the executive committee.

Joint Advisory Council

The joint advisory council is composed of the chairmen of local sections, the chairmen of technical divisions, and the president of the association acting as chairman. The council provides a formal means of bringing members' viewpoints directly to the attention of the executive committee. It meets immediately prior to the February meeting of the executive committee and may attend this meeting upon the invitation of the president.

Local Section Operations Committee

The local section operations committee is composed of the chairmen of the local sections and the executive secretary of the association acting as chairman. This committee, reporting to the president, is responsible for guiding and coordinating the activities of local sections, for planning activities to promote association objects, and for furthering the progress of the sections by disseminating information on procedures and programs which have proved successful in local section operations. In addition, it is the responsibility of this committee to make recommendations to the president and the executive committee on the chartering of new sections.

Although voting privileges are limited to the local section chairmen (or their designated alternates), all local section and district officers are permitted to attend the meetings of this committee.

The local section operations committee meets in the fall and at the February annual meeting of the association to: (1) present recommendations on matters of local section policy to the executive committee and to

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the headquarters staff, (2) provide a mechanism for the mutual exchange of information on local section operations between the various sections, and (3) coordinate joint activities of the sections.

Executive Secretary

The executive secretary is the chief staff officer of the association. He is appointed by the executive committee and reports to the president. His functions include guiding and assisting local sections and districts, encouraging the formation of new sections, and coordinating various national programs to be undertaken by the sections.

Headquarters Staff Liaison

Members of the association staff provide liaison between the headquarters office and the local sections and districts. They assist these groups through periodic visits to section meetings, consultation with section officers, and coordination of local section activities on a national scale.

CHAPTER III—ORGANIZATION OF A LOCAL SECTION

Establishment of a Club

Any group of national TAPPI members may meet to discuss the feasibility of forming a local group. It is advisable to notify the association office of plans for this meeting, so that a representative may attend to describe association policies and suggest a course of action.

If it is decided to form a local group independent of any existing local section, a formal petition for club status should be drafted and signed by 25 or more persons (at least three members of TAPPI) who reside in the area to be served and who are willing to support the group. The area of the proposed club should not conflict with those of established local sections of the association.

This petition should be presented to the local section operations committee for consideration. It is essential that the chairmen of local sections whose areas adjoin those of the proposed club support the petition. If approved, the petition should then be transmitted to the president for the consideration of the association's executive committee.

The cooperation of individuals and companies in the new club's area should be solicited by the leaders of the proposed club and by the association staff.

If it is deemed advisable, funds may be granted to the new group by the association. No rebate of members' dues will be made by the association, since this support is offered only to chartered local sections.

The association staff will consult with the group at appropriate intervals to aid it in qualifying for local section status.

Conditions during club status favorable to chartering include: (1) consistently good attendance at meetings, (2) programs in keeping with TAPPI objects, (3) fiscal soundness, (4) and the support of local companies.

A local section charter shall be granted upon petition to the association by at least three national members of the club and upon approval by the local section operations committee and the executive committee.

Establishment of a District

If a local group decides to seek recognition as a district of an existing section, a petition to that effect shall be presented to the executive committee of the appropriate local section. If the section's executive committee approves the petition, it will then be forwarded to the local section operations committee and the executive committee of the association for their consideration.

If the group is granted district status, it shall be subject to the direction and control of the local section insofar as both agree to this.

Dues rebates will be made to the local section for those members of the district who are members of the association.

The district shall furnish an annual progress report on its activities to the parent local section and to the local section operations committee.

Upon the recommendation of the parent local section and upon receipt of a petition signed by at least three active members of the association residing in the district, the local section operations committee and executive committee may grant local section status to the district.

Establishment of a Local Section

If a charter is granted: (1) formal ceremonies will be held at a meeting called by the newly chartered section, (2) the present local sections affected by the presence of a new section will be notified of the decision by the association, (3) association members located near the new section will be notified, (4) corporation executives located in the territory of the new local section will be notified of the charter grant and asked to continue to support the activities of the group, and (5) headquarters assistance will continue to be available for furthering the growth of the new local section.

Articles of Organization

Each section should adopt articles of organization outlining its operating principles. The following is a suggested outline of such articles. This may be amplified by appropriate bylaws.

Article I—Name and Objects

The section shall be known as the _____ Section of the Technical Association of the Pulp and Paper Industry and is hereinafter referred to as the section.

The objects of a section shall be in harmony with the constitution and bylaws of the Technical Association of the Pulp and Paper Industry.

Article II—Membership

Membership in the section shall consist of active members and associate members.

1. An active member of a section shall be a member of the Technical Association of the Pulp and Paper Industry. An associate member of a section shall be anyone else who is interested in pulp and paper manufacture or in related industries or institutions.

2. Only members of the association may be elected to office in the local section.

3. Applications for admission to section membership shall be made in writing and be passed upon by the

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executive committee of the section (or by a committee appointed for the purpose).

Article III—Dues

The annual dues for membership in the section shall be $—— payable in advance.

Article IV—Officers

There shall be a chairman, a vice-chairman (or vice-chairmen), a secretary, and a treasurer of the section, whose duties shall be the customary ones for each office. These officers shall be members of national TAPPI.

Article V—Executive Committee

The executive committee shall consist of the officers of the section together with such additional members of the section as may be provided for by the section. The section chairman shall serve as chairman of the executive committee.

Article VI—Nominations

Nominations for the officers and other members of the executive committee of the section shall be made by a nominating committee consisting of five members of the section, of which not more than two shall be on the executive committee. The nominating committee shall be appointed by the executive committee at least 3 months before the annual meeting of the section.

The nominations shall be announced to the membership of the section at least 30 days in advance of the annual meeting.

Article VII—Election

The election of the officers and the members of the executive committee shall take place yearly at the annual meeting of the section. Vacancies occurring during the year shall be filled by the executive committee until the next annual meeting.

Article VIII—Annual Meeting

There shall be an annual meeting of the section at a specified time for the election of officers and for the transaction of other business. Ten per cent of the voting members whose dues are paid shall constitute a quorum.

Article IX—Committees

(As established by the section.)

Article X—Approval of Articles of Organization

The articles of organization shall be approved by the Executive Committee of the Technical Association.

Article XI—Amendments

Articles may be amended or new ones adopted at any meeting of the section, provided that a copy of the proposed change has been sent to every member of the section at least 30 days preceding the meeting, at which time it is to be voted upon.

The decision of the association executive committee on any question involving the interpretation of these articles shall be final.

CHAPTER IV—ADMINISTRATION OF THE LOCAL SECTION

Executive Committee

The governing body of the local section is its executive committee, which is responsible for the direction and guidance of the section. The chairman of the section acts as the chairman of the executive committee.

The committee is made up of the officers and a number of locally active members considered able directors of the section because of their past experience and recognized judgment. Usually the success of a local section can be largely attributed to the energy and wisdom displayed by its executive committee.

It is recommended that this committee meet frequently.

Officers

The principal officers are a chairman, vice-chairman, secretary, and treasurer (or a combination secretary-treasurer). They are responsible for implementing the policies established by the executive committee. A greater number of officers may be desirable and might include such positions as second vice-chairman or the separation of the secretary's assignments into those of a secretary and an assistant secretary. Such steps assist in insuring executive continuity in the event an officer must resign.

The association constitution stipulates that local section officers shall be members of the association.

The responsibilities of each position of this expanded executive group are outlined as follows:

Chairman

The chairman is responsible for the administration of the section. He supervises the other elected officers and the members he has appointed to aid in his administration. He is also charged with the responsibility of carrying out the policies established by the section's executive committee. In addition to presiding at meetings, he should direct the activities of the various committees of the section, promote cooperation with the national association, and develop programs aimed at maintaining the general welfare of the section. A suggested duty calendar might include the following:

IMMEDIATELY AFTER ELECTION

1. Set date for the opening meeting of executive committee.
2. Appoint chairman and members of program committee.
3. Attend joint meeting of executive committee and program committee.
4. Provide all officers with copies of the "Manual for TAPPI Local Sections."
5. Arrange for the transfer of all records and files from outgoing officers to new officers.
6. Appoint all other committees.
7. Meet with all appointed committee chairmen to discuss their assigned tasks.

DURING THE TERM OF OFFICE

1. See that program plans for the year are complete well before the first section meeting.
2. Preside at all section and executive committee meetings.
3. Appoint a nominating committee at least three months prior to elections.
4. Appoint an auditing committee, if there is to be one, one month prior to end of fiscal year.
5. Attend (or assign alternate to attend) meetings of the

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local section operations committee and the joint advisory council.

First Vice-Chairman

This officer acts for the chairman in his absence and assists the chairman in assigned tasks. He serves as chairman or member of selected committees. Frequently, he is chairman of the program committee. He should also attend meetings of the local section operations committee when possible.

Second Vice-Chairman

This officer acts for the first vice-chairman in his absence and assists the chairman in assigned tasks. Frequently he serves as chairman of the publicity committee, since this is excellent training for subsequent service as the chairman of the program committee.

Secretary

This officer is responsible for keeping the records of the section. These records include:

1. Names and addresses of members.
2. Status of members (TAPPI and non-TAPPI).
3. Minutes of executive committee meetings.
4. Records of section meetings.
5. Copies of all committee reports.
6. Copies of all section correspondence.

In addition, he is responsible for mailing notices to the membership and for assisting the chairman in the preparation of the annual report to the local section operations committee.

This position is a responsible one, and a member nominated for secretary should have sufficient time to carry out the responsibilities of the office.

Assistant Secretary

To lighten the burden of the secretary and to help prepare a member for the secretary's position it may be desirable to appoint an assistant secretary. This individual can become familiar with the affairs of the section through handling such tasks as recording meeting minutes, sending out mailings to the members, maintaining membership records, and submitting reports and manuscripts to the association office for publication in *Tappi*.

Treasurer

This officer is the custodian of the section's funds and should submit regular financial reports to the membership and to the executive committee. He is responsible for maintaining financial records, collecting dues, applying to the association for dues rebates, issuing disbursements, assisting in the preparation of budgets, and providing a financial report at the end of the fiscal year to the section and to the association.

Section funds should be disbursed only by check signed by the treasurer. The chairman also should have authority to sign checks when it is impossible for the treasurer to do so. Both officials should be bonded.

The treasurer may also be responsible for the property of the local section. Such property includes the banner, gavel, charter certificate

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DU PONT DYE SALESMEN OFFER NEW SERVICE: "ECONOMY CHECK" ON YOUR USE OF COLORS

How long since you've conscientiously set out to modernize the dye formulas in your mill? How long have you been using the same dyes to get that familiar pink or equally familiar yellow? Ten years? Fifteen years? Are you sure you're making colored paper the best, the most economical way?

Because so many paper mills haven't taken the time to review their formulas—and because it's likely that unnecessary expense and trouble can be eliminated by just such a review—Du Pont dye salesmen have launched their new "Economy Check" program.

Here's how this service plan works:

Without cost or obligation, Du Pont thoroughly reviews each of your dyeing formulas. If a less expensive dye will do as good a job as the one you're using, you'll be told about it. If a more costly dye will eliminate a problem that's costing you money in off-color lots, you'll be told about that, too. When the review is completed, you'll have the assurance that your dyeing formulas are up to date in every sense and that you're getting the "most dye for the dollar."

Already Du Pont salesmen have chalked up results in the "Economy Check" program:

Item—A mill had had repeated trouble with two-sidedness in using a given formula. In the course of an "Economy Check," the Du Pont salesman sent a paper sample back to Du Pont's Technical Laboratory where the shade was matched with different dyes. The two-sidedness headache was cured at no increase in cost.

Item—A paper mill had been using a particular red dye for some time with satisfactory results. The "Economy Check" turned up the fact that another red dye would do the job just as satisfactorily and at less cost.

Item—A mill had been turning out a particular yellow shade for years. The dyeing formula "just growed" and hadn't been questioned until a Du Pont salesman found that the shade could be matched with an improved formula at a saving to the mill of $16 a ton!

Ask your Du Pont salesman—or get in touch with the nearest Du Pont district office—to enjoy the benefits of an "Economy Check" on your dyeing operations. We can't guarantee a saving, obviously. Besides, the cheapest formulation isn't necessarily the best. But today, when cost reduction is so important, it's more vital than ever that you pass up no opportunity for economizing. Du Pont is pleased to offer you one of these opportunities.

John L. Ayres, right, Du Pont dye salesman in Pacific Northwest, launches "Economy Check" for a customer by having Du Pont lab review current color formulas. Plan can save money for mills. Johnny Ayres learned his trade during 13 years in dyes lab and 11 years as a Du Pont salesman.

news from Du Pont

3 EASY WAYS TO SOLVE COMMON DYEING PROBLEMS

If you dye mixed pulps or bleached furnishes, or produce heavy shades, you may notice a tendency toward bleeding or graniting. Du Pont supplies three dyeing assistants that can help you obtain better dyeing without changing to more expensive dyes.

Uneven dyeing or graniting

When dyeing mixed pulps with direct dyes, Du Pont Retarder LAN aids level dyeing and reduces graniting considerably. A small amount in the beater often permits lighter pastel shades to be produced, with the same direct dyes you're now using.

Bleeding or "dye burning"

Papers colored with acid or direct dyes sometimes bleed too much in the heavy shades, or suffer "dye burning" on the dryers, or become marked by the felt or dandy roll. "Insonite" dye fixing agent reduces these problems at small cost. Although it gives best results in surface applications, this agent can be added at the beater.

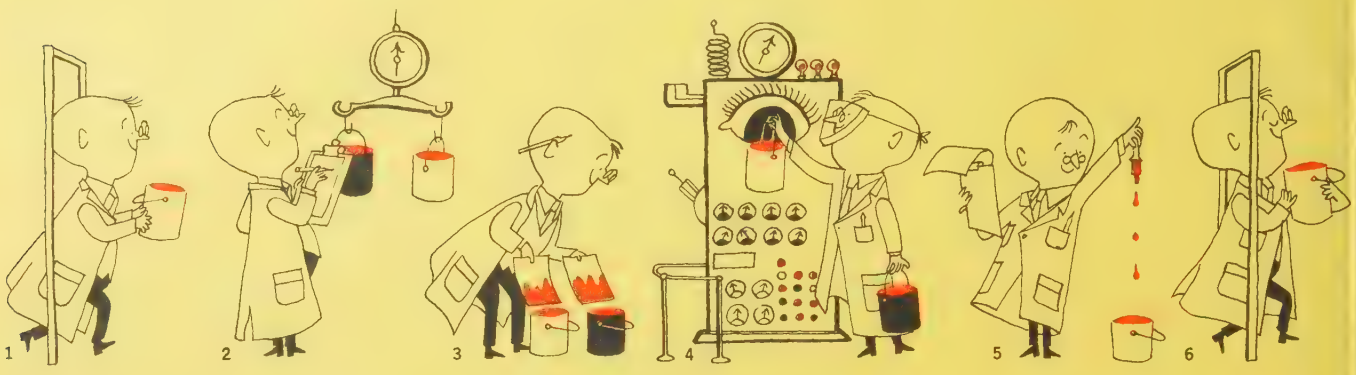
Water spotting or bleeding

These problems often occur when basic dyes are used to color bleached furnishes. Because of their affinity for such furnishes, the dyes may not set properly. Du Pont Mordant BS overcomes the problem, yet does not give the dulling effect of tannic acid. It is used with surface stained grades but can be applied in the beater.

VISITOR SEES DU PONT PUT DYES THROUGH 28 QUALITY CONTROL STEPS

After seeing Du Pont quality control in action, a recent visitor to the Technical Laboratory expressed amazement that any mill would jeopardize a run worth hundreds of dollars for the sake of saving a few cents in "bargain" dyes.

He followed the various crude charges in a dye lot through *28* separate steps. He saw how Du Pont checks and rechecks a dye lot against the standard . . . how three different technicians check each sample to guard against bias. This simplified drawing shows just the highlights of the entire quality control procedure.



(1) Technician takes sample to lab. (2) An equal weight of dye standard is prepared. (3) He makes hand sheets of sample and standard. (4) Accurate visual and photospectrometer comparisons are made. (5) Report is written . . . necessary corrections are made . . . all lab steps are repeated at several production stages. (6) Highly accurate dye batch is shipped to customer.

news from Du Pont

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Is your problem listed here? Check these items:	These, or related, chemicals and Du Pont experience could help you:
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Basic Dyes	Du Pont Mordant BS
De-inking Assistance	"Alkanol"® HCS surface active agent
Dye Fixing	Du Pont Mordant BS "Insonite"® dye fixing agent
Dye Leveling	Du Pont Retarder LAN
Felt Washing	"Alkanol"® HCS surface active agent "Duponol"® RA surface active agent
Graniting Retardation	Du Pont Retarder LAN
Linting Reduction on Printing Grades	"Zoron"(T.M.) WSP resin finish
Pulping Assistance	"Alkanol"® HCS surface active agent
Safety Paper Chlorine Indication	"Chlorostain"® N chlorine indicator
Starch Insolubilization	"Zoron"(T.M.) WSP resin finish
Wet Strength Imparting-surface Application	"Zoron"(T.M.) WSP resin finish

There's probably a Du Pont chemical that can help you. We offer a broad range of detergents, emulsifiers, resins, lubricants and specialty products such as water repellents, electrically-conductive chemicals, wetting agents, and many others. For complete data, write the district office nearest you.

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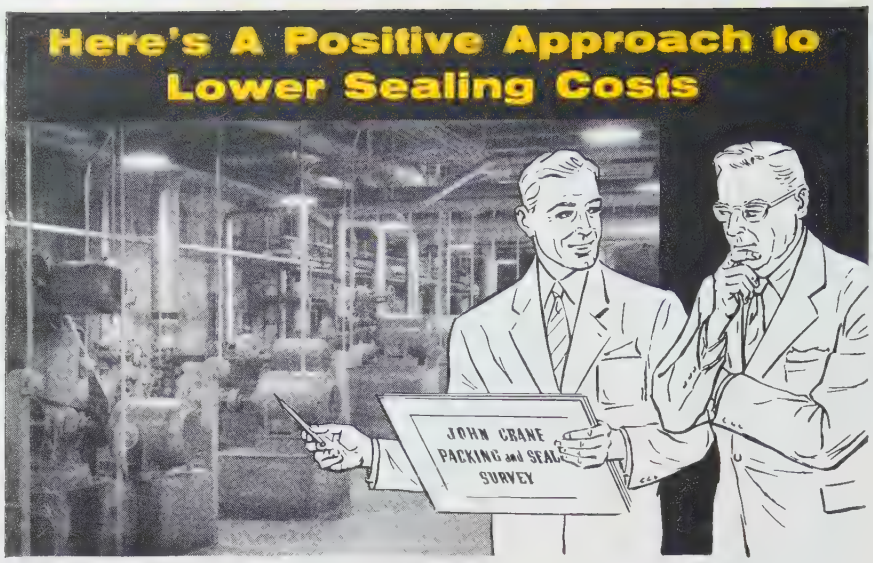

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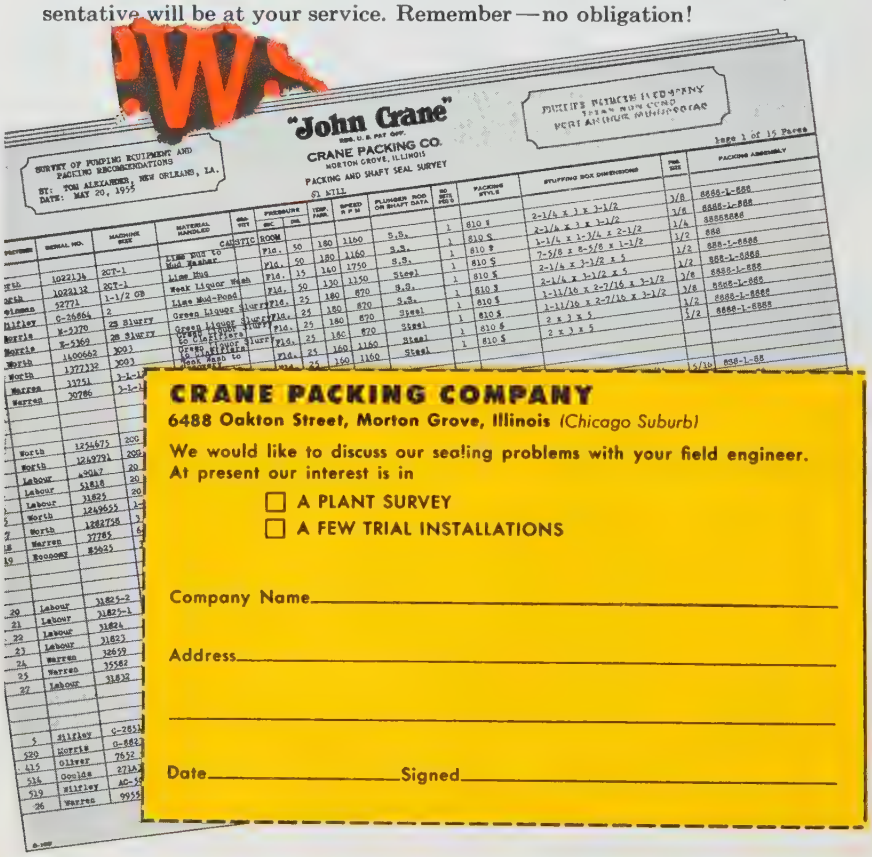
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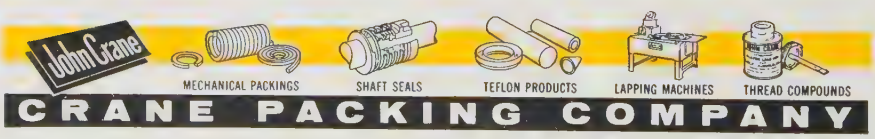

and other items requiring special custodianship.

CHAPTER V—LOCAL SECTION COMMITTEES

The chairman has placed upon him a great responsibility for conducting successfully the affairs of the section during the year. He has been selected by his section because it was felt he would provide capable leadership for achieving its objects.

When he takes office, he should be mindful of the accomplishments of his predecessors, the success of past meetings, the interests of the membership, and the financial position of the section. By accepting the position, he makes himself personally responsible not only for maintaining this standard but wherever possible, improving it. In order to carry out his important responsibilities, it is evident he must carefully select members for his team who, given sufficient authority and responsibility, will cooperate in assuring a successful year.

Many organizations have learned that where voluntary efforts are concerned, it is most important that assignable work be spread among the membership to the greatest possible extent. The net effect is to generate greater membership interest through participation in activities. However, assigned tasks must be spelled out and clearly understood in order to overcome the usual reluctance of many individuals to serve as officers or on committees.

It is with the hope of assisting the chairman and the other officers that the functions of various suggested committees are outlined in the succeeding pages. Each of these committees should be made up of at least three section members and headed by a willing and capable chairman. Because the success of a section depends so much on the quality of its programs, the section on the program committee is outlined in considerable detail.

Program Committee

The position of chairman of the program committee is extremely important, and the man selected for the position should have provided ample demonstration of his ability to organize, plan, and follow through on any previously assigned tasks.

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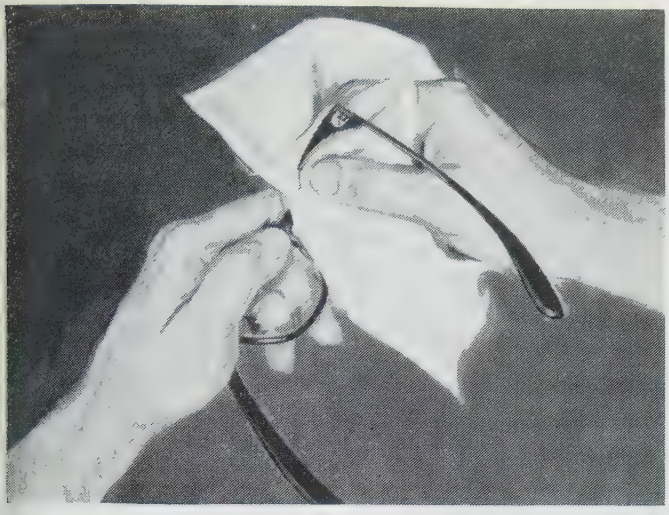

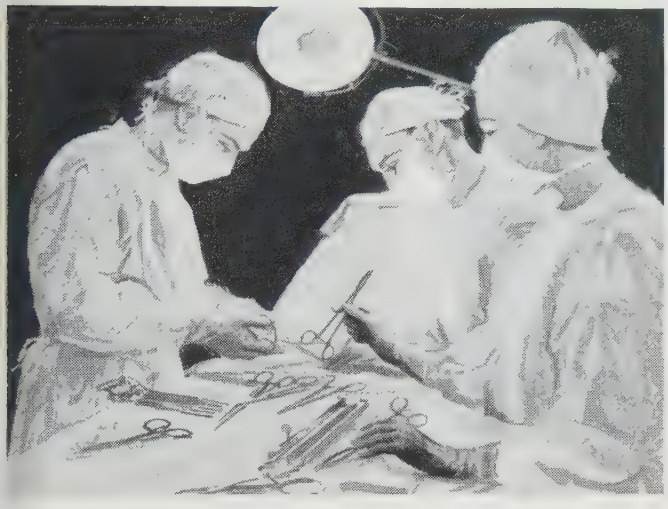

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AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

If the first vice-chairman is the program chairman (as some sections have specified in their constitution and bylaws), it is almost mandatory that the second vice-chairman be a member of the committee to become familiar with the many details connected with running this committee.

With a view toward aiding in the selection of future program chairmen, some sections have found it desirable to assign each member of the committee to a single program, and it becomes his responsibility to organize the program for that date.

After appointment and before meeting with the executive committee to discuss a program for the coming year, the program chairman and his committee should analyze the programs presented in recent years, consider the manufacturing processes of the pulp and paper mills and converters located in the section's territory, consider the dates set aside for TAPPI functional conferences and other meetings, analyze the job classifications and interests of the membership, and study the speakers' directory and film listing provided by association headquarters. The program committee should then be prepared to discuss and formulate a season's program with the help and guidance of the executive committee.

Because of the limited number of technical meetings which a section can hold, it is important to plan programs which will interest the majority of both present and potential members.

Many sections find it most desirable to complete their program arrangements by midsummer so as to be able adequately to publicize these plans and thus stimulate interest in coming attractions.

Relations with the Guest Speaker

After writing to and securing the acceptance of a speaker, a basic procedure to follow should include these important points:

1. Put the speaker on the mailing list. This will give the speaker an idea of the kind of programs presented by the section. It may even be desirable (if he lives nearby) to invite him to attend one or two meetings prior to his appearance to learn firsthand how the section conducts its program.
2. Secure material for publicity. Ask the speaker for a photograph and a brief autobiography which may be included in the program announcements. The speaker might also be asked to provide a brief abstract of his talk in order to create further interest in his subject.
3. Learn the needs of the speaker. If the speaker is traveling from some distance, determine his hotel and transportation requirements and offer help in securing hotel space and reservations for travel accommodations. The committee should also know what facilities the speaker will need during his talk, such as chalkboards, projectors, easels, and pointers. He may wish to visit certain mills or have the committee advise certain people he may know of his plans. These and other services should be performed by the program committee acting as host to the guest.
4. Keep the speaker informed. Let him know the time of the meeting including the dinner, the exact location, and the amount of time allocated on the program for his lecture. Meet the speaker when he arrives in town and see that he is properly escorted after the meeting.
5. Be sure that the program committee and the speaker clearly understand the proposed scope of the paper. This is particularly important when the speaker is a supplier to the paper industry and is not familiar with the wishes of the program committee. Unless notified to the contrary, he may assume that this speaking assignment entitles him to advertise his company's products in an inappropriate manner.

ANHEUSER-BUSCH, INC.
ANHEUSER-BUSCH, INC.
Sign of highest quality
STARCHES • DEXTRINES • GUMS
For all phases of paper manufacturing and converting... beaters, tub sizing, coatings, calendering, corrugating and laminating
all fine products...
from the corn we took off the cob
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Bulk Corn Products Division
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QUALITY

here's a way to safeguard BOTH . . .

PROFITS

• check your crowns • check your nips

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S-W NIP-WIDTH TESTER

As you probably know, a ¼" variation in nip width may indicate as much as 150 lbs. of localized *extra pressure.*

When your rubber roll is installed it is too late to change the crown. Yet, with the S-W Nip-Width Tester you can tell in advance how your rolls will perform. Results are improved processing and considerably longer roll life. These, of course, help profits.

For information about the S-W Nip-Width Tester get in touch with your S-W Sales Engineer.

75th YEAR S-W INC.

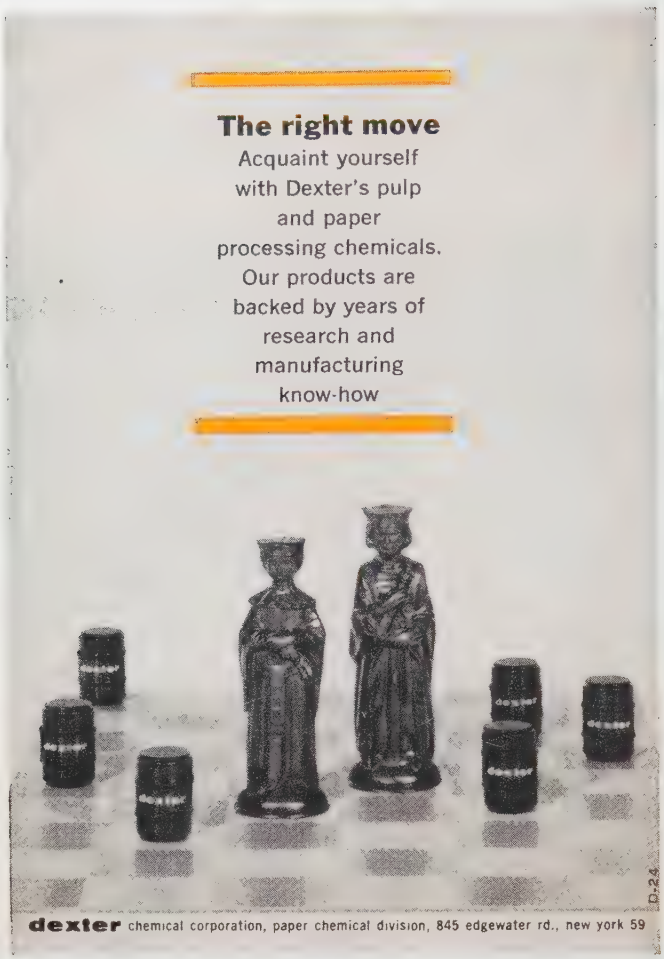
- proved in over 100 mills in the past 2 years
- accurate readings plotted on graph paper permit adjustments to improve processing

more tons from every cover because of technical leadership

STOWE-WOODWARD, INC.

Newton Upper Falls, Mass. *Neenah, Wisconsin* *Griffin, Georgia*

on the West Coast • HUNTINGTON RUBBER MILLS, INC. • Seattle, Washington • Portland, Oregon • Port Coquitlam, British Columbia, Canada



6. Acknowledge his contribution. A prompt letter of appreciation should follow the speaker's appearance. The letter may be written by the committeeman responsible for his appearance, since previous correspondence occurred between the two. However, it is just as correct for the chairman of the section to write the letter, as spokesman for the entire membership.

Between Dinner and Main Talk (Evening Meetings)

Many times a section program can be built up by scheduling a short 20 or 30 min. subject between the dinner and the main talk. This can be an attractive part of any program, and a wide variety of individuals may be available for brief talks. Such people as a local celebrity, a well known sports figure, or some local official can usually be counted on to provide program color. At other times motion pictures may be shown which deal with a subject of general interest. It is advisable, however, that the principal speaker start no later than 8:30 p.m. so that drowsiness and "early leavers" do not reduce the program's effectiveness.

Suggested Special Occasions

Executives' Night. It is desirable that top management become familiar with and understand the work of the local section. One way of accomplishing this is to designate one meeting a year as "executives' night," to which would be invited the top executives of the pulp and paper firms and converters located within the section's territory.

The speaker for this evening should be selected with care and, if possible, be someone capable of presenting a message of special interest to the executives.

A suggested policy to follow may be along these lines: (1) confine invitations to top executives, (2) send the letter of invitation at least a month before the meeting, (3) always seat the executives at the head table, (4) do not call on an executive to speak unless he knows he will be asked to say a few words, (5) leave the selling of the section to an impression of its activities, not to statements expounding its merits.

Students' Night. Everyone recognizes the value of creating student interest in the many phases of the pulp and paper industry. The responsibility for making the industry attractive is, of course, a constant one and it may be desirable to devote one special night to the students.

Here again, the program should be designed to indicate the nature of the industry and the caliber of people who are its technical backbone. Care must be taken in the selection of speakers, with special emphasis on how well they can adapt their topics to the needs and interests of the students.

This night might also be chosen as Awards Night for students or younger members who have competed for local section prizes, and it may be well to have the top two or three papers presented by the authors themselves.

If there are nearby schools where interest in TAPPI and local section activities can be developed, it might be well to provide transportation to accommodate those students who have indicated their desire to attend. Publicity in school papers and letters to or personal contact with teachers should enlarge substantially the attendance of these potential members of the association.

No fees should be charged section guests such as those mentioned above. Where large numbers of students are invited to an evening meeting, however, the section may wish to have them arrive following the dinner so as to avoid an excessive drain on the section's finances.

Other Meetings

There are other special meetings which a section may hold. Some sections may find it desirable to hold five or six regular evening meetings and schedule full-day or 2-day meetings jointly with nearby sections once or twice a year. Joint meetings with other associations may be desirable. Plant tours, symposia, golf parties, ladies' night, picnics, and other events may be planned to enliven interest in section activities.

Many sections honor the memory of deceased members by holding meetings in their names. Frequently such meetings feature awards named for the men to be honored.

Meeting Critiques

Because of the importance of the program to the success of a local section, it is advisable that there be a brief critique immediately following each section meeting. This could be a function of the executive committee with the secretary recording the strong and weak points of the meeting. This information will be of considerable value to future program committees and in preparing the section's meeting reports for publication in *Tappi*.

add NORFOLK, VIRGINIA... to the growing list of TGS local distribution terminals for MOLTEN SULPHUR.

And how does Norfolk keep its 20,000 gross ton storage capacity stocked well ahead of demand?

By our new 15,000 ton tanker, the Marine Sulphur Queen, which on a 10 to 12 hour turn around schedule takes on cargo at our new large main supply terminal at Beaumont, Texas. From Norfolk we are supplying Mid-Atlantic plants by tank car and tank trucks.

As part of a broadening program of molten sulphur deliveries, TGS is now operating several large distribution terminals located in major sulphur consuming areas.

Carteret—molten • Cincinnati—molten
Norfolk—molten, solid • Tampa—molten, solid
Other terminals are in the planning stage.

(PHOTO): The MARINE SULPHUR QUEEN heading into Norfolk.

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75 East 45th Street, New York 17, N. Y.
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Sulphur Producing Units:
NEWGULF, TEXAS • MOSS BLUFF, TEXAS • FANNETT, TEXAS
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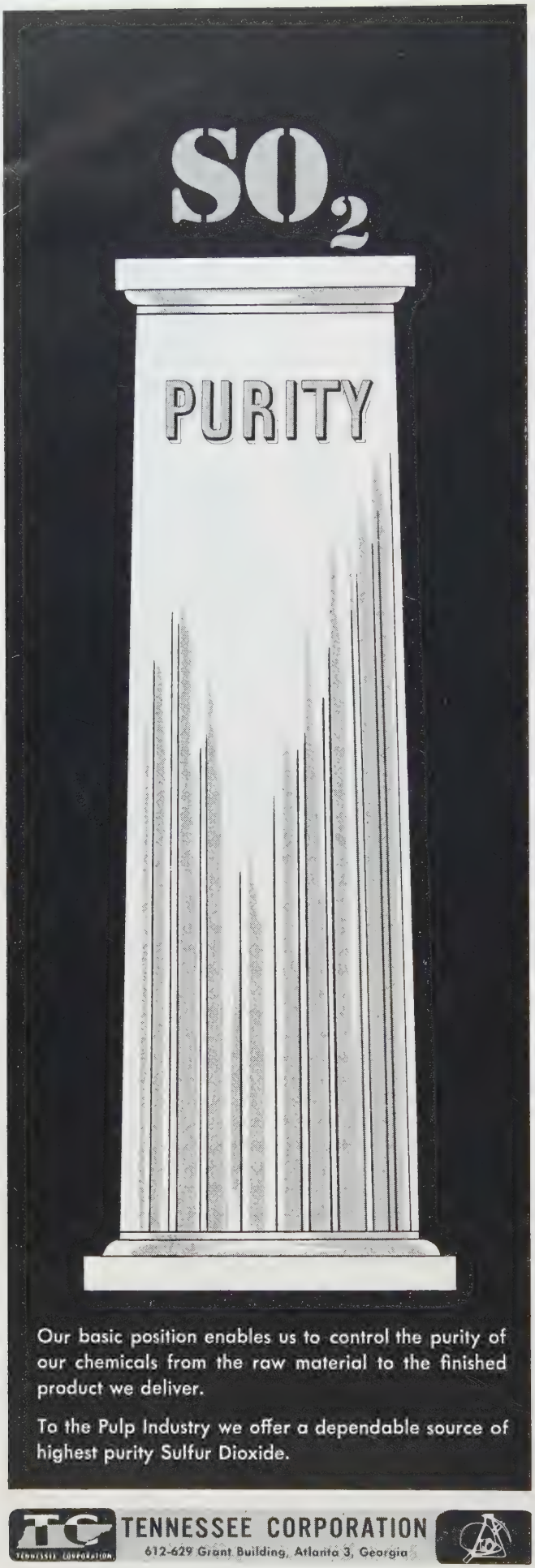

SO_2
PURITY
Our basic position enables us to control the purity of our chemicals from the raw material to the finished product we deliver.
To the Pulp Industry we offer a dependable source of highest purity Sulfur Dioxide.
TENNESSEE CORPORATION
612-629 Grant Building, Atlanta 3, Georgia

Publicity Committee

This committee should work closely with the secretary and the program committee, the former for coverage of overall section activities and the latter for coverage of individual program details.

Assigned tasks may include:

1. Preparing and sending releases to selected media, including *Tappi*, in time to meet printing deadlines.
2. Keeping current record of exact name, title, and address of persons at media who have agreed to accept section publicity releases.
3. Keeping a record of publicity received. (A scrapbook for proofs or actual material printed.)
4. Providing a photographer when needed.
5. Preparing advance publicity for meetings.

This committee should utilize the following general opportunities for publicity:

1. Before and after all section meetings and activities.
2. Section elections and appointments.
3. Activities of individual members.
4. Awards and other forms of recognition.

There is no rigid format for a news release, but such publicity should answer as many of the following questions as possible.

1. What is the name of the group or individual?
2. What happened or will happen?
3. When did or will it happen?
4. Where did or will it happen?
5. What was or will be the occasion?
6. What are the names of people connected with the occasion?

Whenever possible, it is most desirable to include photographs of individuals or groups mentioned in the release.

Membership Committee

This committee should work closely with the secretary.

Assigned tasks may include:

1. Contacting visitors at local section meetings in cooperation with the arrangements and hospitality committee.
2. Contacting national association members who do not belong to the local section, using the geographical roster in the association yearbook and requesting aid from the headquarters staff.
3. Contacting individuals who have dropped their section membership.
4. Contacting members who attend too few meetings.
5. Contacting new national association members, using the information published in *Tappi*.
6. Making available national association membership applications at local section meetings.
7. Keeping records of attendance at meetings and supplying this information to officers when needed.
8. Acquainting new section members with the aims and objects of the association and the local section.

Arrangements and Hospitality Committee

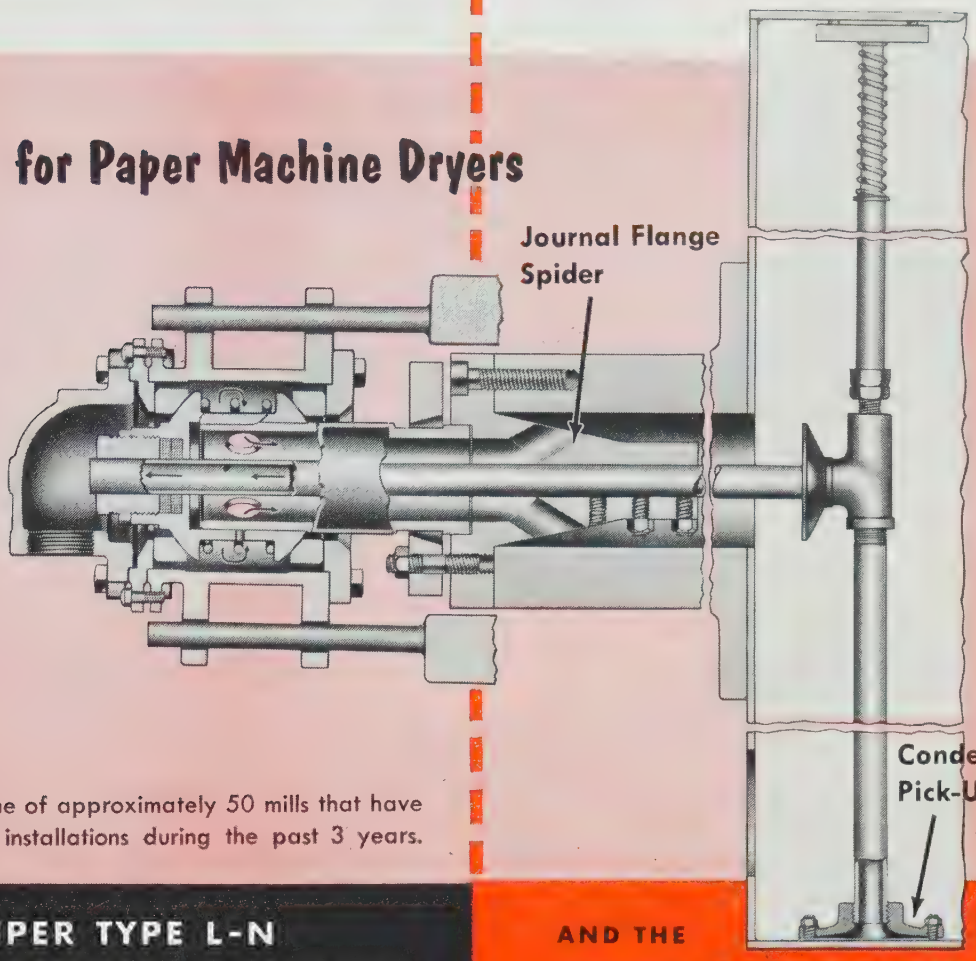
Because of the nature of its assignment, the arrangements and hospitality committee should work closely with the program committee.

Assigned tasks may include:

1. Securing meeting rooms in the building as directed by program chairman.
2. Selecting menus.
3. Providing special materials for meetings, such as projectors, screens, chalkboards, pointers, easels, and public address systems.
4. Ensuring adequate checking facilities for clothing.

You've never seen a Combination like this*...

for Paper Machine Dryers



* Unless yours is one of approximately 50 mills that have made tests and installations during the past 3 years.

SUPER TYPE L-N

JOHNSON JOINT with "Quick Release" Nipple

AND THE

NEW JOHNSON ROTARY SYPHON

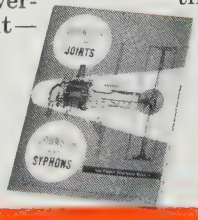
Best Design Yet for getting steam into dryer rolls with rotating syphon pipes. Needs no lubrication or adjustment. Has only a few simple parts—less chance of trouble plus easier field servicing. Assembly plate provides ready access to syphon pipe.

Floating Action—Rod supports carry all the real weight, let the rotating assembly "float" freely inside. Adaptable for machines with open or enclosed gearing.

SUPER Construction...*and Stamina*—Teams rock hard "Green Streak" seal rings with special Ni-Chrome plating, slashes friction load and increases service life.

Easy on...and off—"Quick Release" nipple uses powerful wedging action to lock joint in place. Install it—or remove it—with just an end wrench.

Engineers' Data Book summarizes research behind this new development, has full technical information. Ask for copy of: "Condensate Behavior in Paper Machines."



Better Drainage of dryer rolls results from a new concept of condensate pick-up design. Holds condensate to a minimum. Rotary Syphon can be located any place along the dryer shell. Helps to reduce horsepower requirements.

Higher Roll Temperatures—Thinner condensate film means better transfer of heat units to dryer shell. Better drying can be translated directly into increased production.

Easier Installation—No need to get inside dryer to drill and tap dryer head. Install right through manhole. For rolls with handholes only there's even a journal-inserted rotary syphon.

Reduced Maintenance—Only a few simple trouble-free parts. Ends bearing wear caused by unnecessary water weight and prolonged "cascading." Easily removed for inspection.

Trial offer still goes. We'll gladly furnish a pair of Joints and Syphons for 90-day trial in your own mill, without cost or obligation. Ask for details.

THE JOHNSON CORPORATION

843 Wood St., Three Rivers, Mich.

Rotary Pressure Joints • Direct Operated Solenoid Valves

5. Providing facilities for registration and ticket selling.

6. Selling tickets and registering members and guests. (If a guest is a potential member, the committee should obtain his full name, address, occupation, and company affiliation.)

7. Welcoming prospective members and seeing that they are seated next to local section members who may interest the guest in joining the section.

8. Seeing that new members and guests are made welcome and acquainted with active local section members.

9. Providing necessary table and seating arrangements in the meeting room and the proper placement of the national flag, TAPPI banner, microphones, gavel, and other items requested by speakers.

10. Returning any borrowed or rented equipment, and storing materials owned by the section, such as the banner and gavel.

Educational Guidance Committee

This committee should work closely with the chairman and the association headquarters office in implementing programs developed by the association and the local section to interest secondary school students in technical education and in technical careers in the paper industry.

Assigned tasks may include:

1. Arranging for high school students and teachers to attend a local section meeting.
2. Arranging for students and teachers to visit a local mill.
3. Sponsoring a high school or student essay contest on the industry.
4. Providing speakers on the pulp and paper industry for local schools and colleges.
5. Placing books on the industry in school and public libraries.

Publications Committee

This committee should work closely with the secretary and the program committee to keep abreast of all section activities. It should assist those presenting papers at section meetings in the preparation of their material for publication in *Tappi*.

An assigned task might be the editing and publishing of a section newsletter. This newsletter may contain features such as the following:

1. Publicity on the next meeting.
2. Comments on last meeting.
3. Activities of national association.
4. Activities of individuals in section.
5. Events of interest in the section's territory.
6. Messages from the chairman.

The newsletter serves not only as the chief medium of communication within the section but as a means of attracting new members and maintaining management support of the section.

The type of newsletter will, of course, vary from section to section, but it is important that the cover format does not undergo radical changes from year to year. The newsletter should be easily identifiable and have a reasonably consistent format.

Sections issuing a newsletter should put the headquarters office and other local sections on their mailing list to acquaint others with what the section is doing. Copies should be addressed to the chairman of each local section.

Awards Committee

This committee should work closely with the chairman and the executive committee in the presentation of original papers in local section competitions.

Section policy and needs will dictate the nature of the awards program. Some sections prefer to limit the awards to junior members who need an incentive to prepare a paper for presentation and who may profit the most from the experience of preparing and presenting a paper.

The following recommendations may be helpful in establishing rules for awards to junior members:

1. Eligibility of contestants. A person to be eligible to receive a junior prize award should be a member of a local section, and be actively engaged in the pulp, paper, and allied industries.

2. Basis for Judging Papers. The judges should grade the papers submitted on the basis of four factors, each weighted to arrive at the final grade: (1) originality—35 points, (2) scientific and practical value—35 points, (3) structure and composition—20 points, and (4) presentation—10 points.

3. Selection and Number of Judges. Judges of papers presented for competition in local section prize competition should not be less than three in number and should be appointed by the executive committee of the local section.

4. Subject Matter of Papers. Papers may be presented on any subject dealing with the pulp and paper industry, including the raw materials and the end products.

5. Presentation of the Papers. All papers are to be submitted to the judging committee, which will determine which shall qualify for oral presentation. The accepted papers shall be presented in the presence of a majority of the judging committee at a regular meeting of the local section.

6. Nature of the Award. If a monetary award is made, the amount and number of the awards shall be at the discretion of each local section.

7. Publicity for Competition. Winners should be given appropriate recognition in local newspapers and in the trade journals. Competition of sufficient merit should be submitted for publication in the recognized organs of the Technical Association.

Nominating Committee

This committee should work closely with the chairman and the executive committee. It should be appointed approximately three months prior to elections and should announce nominations in the publicity sent out prior to the election meetings.

Assigned tasks include:

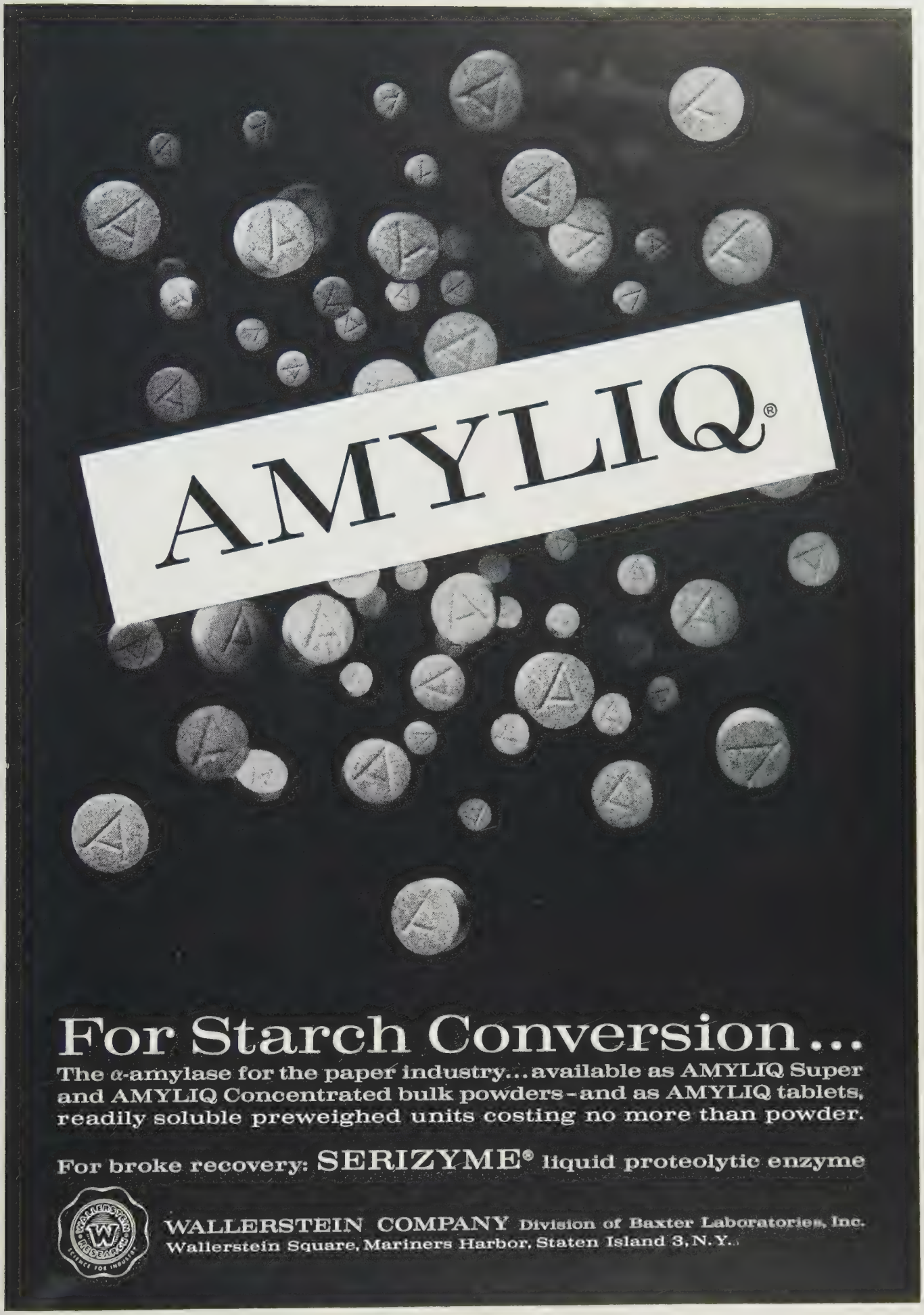
1. Nominating a slate of local section officers for the following year.
2. Securing consent of nominees to have their names appear on the ballot.
3. Presiding during that portion of the election meeting when nominations are presented and elections are held.

Plant Tour Committee

This committee should work closely with the program committee.

Assigned tasks include:

1. Contacting plant officials when a tour is contemplated. (Final arrangements should be made not less than 2 months before the tour.)
2. Compiling list of those who are planning to take the tour.
3. Seeing that proper transportation is arranged.
4. Providing advance information about the plant and the operations to be seen on the tour. (Plant publicity departments may be able to provide this material.)
5. Conducting and being responsible for group while on the tour.
6. Writing letters of thanks to plant officials after the tour. These letters may go out over the section chairman's signature.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For Starch Conversion...
The α-amylase for the paper industry... available as AMYLIQ Super and AMYLIQ Concentrated bulk powders – and as AMYLIQ tablets, readily soluble preweighed units costing no more than powder.
For broke recovery: SERIZYME® liquid proteolytic enzyme
WALLERSTEIN COMPANY Division of Baxter Laboratories, Inc.
Wallerstein Square, Mariners Harbor, Staten Island 3, N.Y.

Auditing Committee

This committee should work closely with the chairman and the treasurer. It may be appointed approximately one month prior to the end of the fiscal year. Frequently, its members may include an accountant from one of the mills in the area.

Its assigned task would be the audit of the books of the section immediately after the end of its fiscal year.

CHAPTER VI—FINANCES

Sound financial policies and procedures are basic to the success of a local section. These include developing a budget and operating within it, accumulating an adequate reserve fund for contingencies, and maintaining simple but orderly financial records.

Development of a Budget

Estimates of income and expenses at the beginning of the fiscal year should be based on the size of the membership and the activities planned for the ensuing year. In developing the budget, the following estimates should be made:

1. Income from dues of local section members.
2. Income from rebates of national association dues.
3. Income from meeting registration fees based on an analysis of past attendance and the number of meetings planned for the coming season.
4. Anticipated expenses for meetings.
5. Incidental expenses of the secretary and treasurer.
6. Incidental expenses of each committee.
7. Sum to be allocated to the reserve fund.

After the budget has been developed and approved, a periodic comparison of the budget with actual income and expenses should be made to insure financial control of the section's activities.

Reserve Fund

An adequate reserve is necessary in order that the section will not find itself in a precarious financial position resulting from insufficient income to meet operating expenses. A reserve equal to the annual total expenses of a section is desirable. Because of the limited financial operations of a section, it may take a number of years to accumulate a sufficient reserve. While an adequate reserve is highly desirable, an excessively large treasury is unnecessary and may reflect inadequate services to members.

Financial Records

The basic books for the treasurer should include a receipts register, a disbursements register, and a cash account record. Examples of such bookkeeping forms are shown below.

Of prime importance is the recording of all income, its source, all disbursements, and the purpose for which these payments were made.

At the end of each month the receipts and disbursements registers should be totaled and entered in the cash account register as shown in the examples.

Following the close of the fiscal year the treasurer shall submit to the association staff a financial statement for the section on the form shown in the appendix.

Rebates of National TAPPI Dues

A reimbursement will be made to each section in accordance with Article XII, Section 4 of the association constitution, which states:

> "Each local section may receive annually for local use such portion of the annual dues of its members as may be authorized by the executive committee, said amount not to exceed 10% of the paid association membership dues for the then current year of the members of the section."

In order to receive the dues rebates for national association members, the local section treasurer should forward to the national headquarters an annual list of the membership. This should be forwarded prior to November 15, so that reimbursement can be made before the end of the calendar year. The membership list submitted shall include the names and addresses

Receipts Register

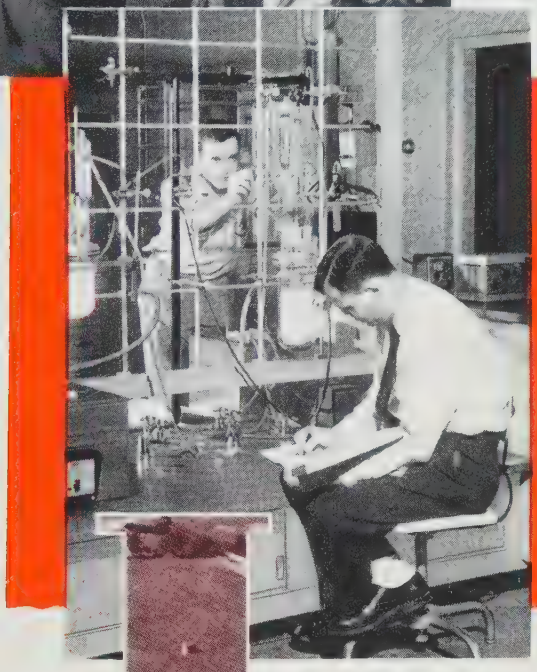
			Credit			
					TAPPI member	
Date	*Received from*	*Debit cash*	*Mtg. fees*	*Affil. dues*	*Dues*	*Rebates*
1/3/61	Reception Com.	90.00	90.00			
1/5/61	John Taylor	5.00		5.00		
1/5/61	Fred Cook	3.50			3.50	
1/10/61	TAPPI	202.50		5.00		202.50
1/28/61	Peter Hill	5.00		5.00		
1/31/61	January Total	306.00				

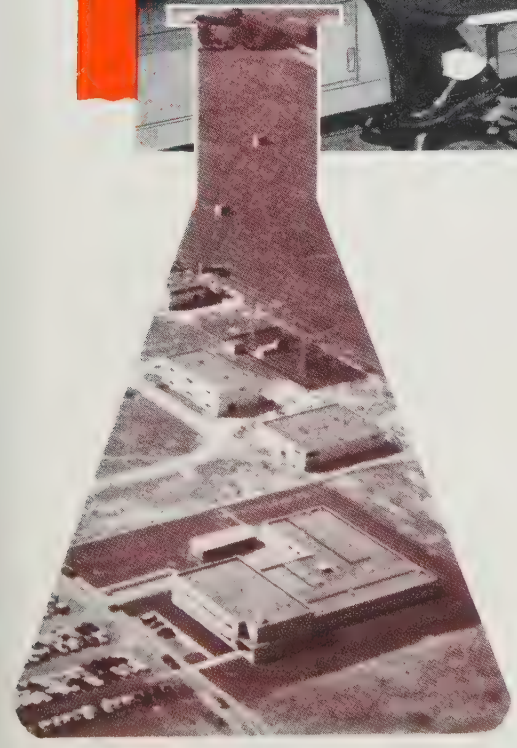
Disbursements Register

				Debit			
Date	*Check no.*	*To whom paid*	*Credit cash*	*Dinners*	*Postage*	*Prntg.*	*Staty.*
1/3/61	105	Browne Hotel	75.00	75.00			
1/12/61	106	Secretary	20.00		20.00		
1/20/61	107	Stand. Prntg. Co.	30.00			30.00	
1/20/61	108	Crown Off. Supp.	5.00				5.00
1/31/61		January Total	130.00				

Cash Account

Date		*Debit*	*Credit*	*Balance*
1/1/61	Cash on hand			703.00
1/31/61	Receipts—January	306.00		
1/31/61	Disbursements—January		130.00	
2/1/61	Cash on hand			879.00





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Starting point for the finishing touch that makes your product BETTER . . .*

*Marmix®

RESIN & RUBBER LATICES

BETTER PAPER PRODUCTS—you can make them today, at lower cost with MARMIX Latices. Used as saturants or additives, they make stronger, tougher products—provide extra resistance to tear and delaminations, insure greater protection against moisture, grease, oils and chemicals. You must try it to know it. Samples and technical assistance are yours for the asking. Write Dept. Y-5

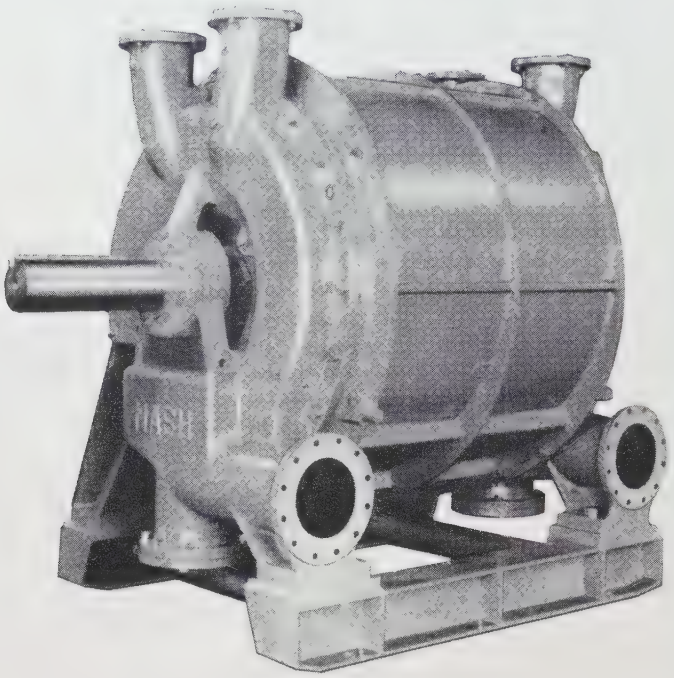
MARBON CHEMICAL DIVISION **BORG-WARNER**

WASHINGTON WEST VIRGINIA

NASH

Paper Mill Vacuum Pumps Designed for Every Desirable Quality, and the First of these is

DEPENDABILITY



When just 3 days lost production on a paper machine can cost more than the vacuum pumps, dependability is the vital factor in pump selection.

Nash Vacuum Pumps are dependable because they are built big enough and heavy enough to stand the pounding of around the clock production, day in and day out. They are reliable because they have only one moving part, and that rotating without wearing metallic contact. They are reliable because the heavy duty ball bearings are located outside the pump casing where they are accessible. They are reliable because they operate at the low speeds necessary for long life and reliable operation.

Nash Vacuum Pumps have been proving their ability to insure uninterrupted production in leading paper mills for nearly a half century. Install them and be safe.

The new Nash 5308-A shown above, has four separate suction inlets, each of which functions independently of the others. This offers the machine operator great flexibility, since these may be used in any desired combination to produce a variety of capacities and vacuums.

NASH ENGINEERING CO.

South Norwalk, Connecticut, U.S.A.

of all who have paid their yearly dues to the section and have received some distinct service from the section. On this list the names of national association members can be checked to indicate those eligible for the dues rebate.

Membership Dues

Most local sections have set moderate dues for their members. In many cases the local section dues of association members are at least $2.00 below those of affiliated members, because of the $2.00 dues rebated to the section for its association members.

CHAPTER VII—REPORTS

Two reports are required of each local section by the national association. Both can be submitted on the forms provided by the association (see Appendix). These reports are:

1. Annual Progress Report

This report summarizes the meetings and activities of the section during the year. The purpose of the report is to bring to the attention of other sections those programs and ideas which have proved successful, and to provide a written record of the activities for use by the section officers and program committee in planning future meetings. This report should be mailed to the national office before July 1 for publication in the August issue of *Tappi*.

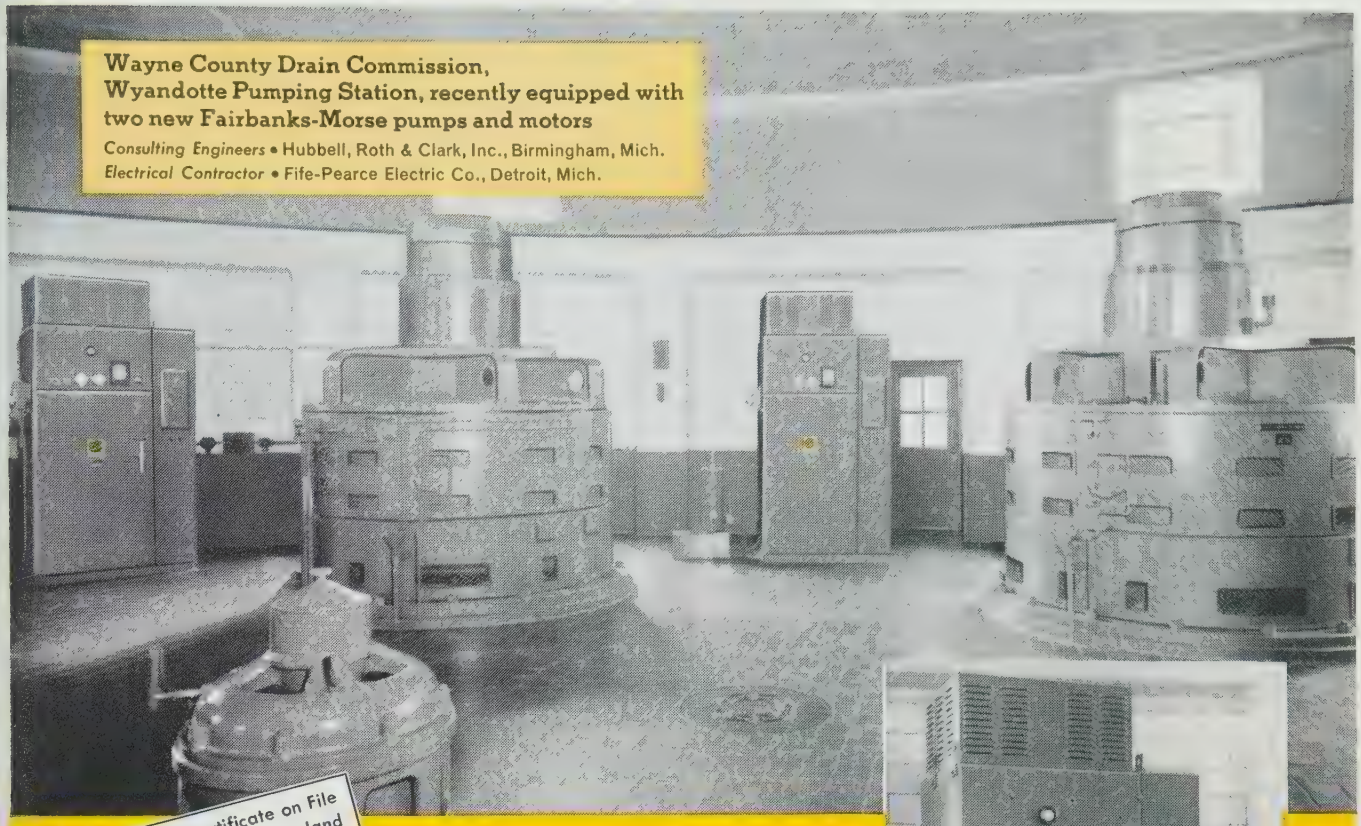
2. Financial Report

This report outlines the financial condition of the section and should be sent to the association headquarters at the time of the request for a rebate of members' national dues.

CHAPTER VIII—HEADQUARTERS SERVICES

The executive secretary and association staff are available for special assistance to local sections and districts. Visits are made to local sections, districts, clubs, and groups who have indicated their interest in organizing a club.

The headquarters staff also sends to the section chairman a periodic listing of speakers who may be available for section programs. The listing contains the name, address,



Wayne County Drain Commission,
Wyandotte Pumping Station, recently equipped with two new Fairbanks-Morse pumps and motors

Consulting Engineers • Hubbell, Roth & Clark, Inc., Birmingham, Mich.
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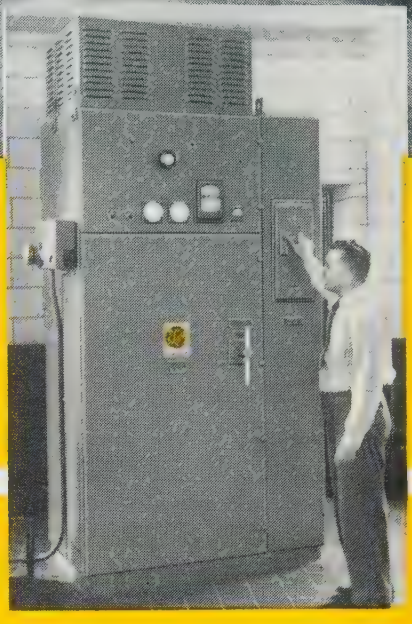
Certified Fault Protection WITHOUT FUSES!

EC&M Fuseless Starters

ELIMINATE FUSE PROBLEMS & COSTS



Now you can get full fault protection without the problems associated with fuses. EC&M's fuseless starters have certified interrupting capacities of 100,000 KVA at 2400 volts, 150,000 KVA at 4800 volts — an important consideration when starters were selected for the 1250-hp, 4800-volt starters at Wyandotte Pumping Station. This inherent fault protection is an EC&M "exclusive" — and is available with no first-cost premium.

EC&M starters are safe and easy to maintain. A three-way door interlock gives positive personnel protection, and an interlock is provided between the contactor and disconnect switch. Disconnect blades are visible in the open position when the door is open. No roll-out or draw-out needed for maintenance. All six contacts can be replaced without special tools in 10 minutes or so.

These cost-saving features make EC&M starters the logical choice for 2200-4800 volt motor drives.

TYPICAL SAVINGS WITH EC&M STARTERS

	Fused Starter	EC&M Fuseless Starter
Cost of 1250-hp 4800-volt Starter	$xxx.xx	Same as Fused Starter
Spare Fuse Costs: Set of 3 Spare Fuses for 1250 hp	$470.00	0

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and affiliation of each speaker and the title of his paper. This listing is to aid the section's program and executive committees in planning their meeting programs.

As another aid to the sections the headquarters staff provides a list of films which might be of interest to local section members. These films are generally available at no charge, and sections desiring films should follow the instructions shown in the listing.

Copies of association literature are also available, and badges, badge holders, and registration cards may be obtained from the office at a nominal charge.

CHAPTER IX—ASSOCIATION PROGRAMS

Among the various programs of the association are several which affect the local sections. A description of these activities follows.

Technical Divisions and Committees

There are eight technical divisions, each having within it those committees whose scopes are interrelated. Each committee concerns itself with improving the industry's technology in a specific field. This is accomplished by carrying on committee projects, by arranging for the presentation of papers at technical meetings, and by collecting and disseminating other technical material. The successful efforts of these committees are shown by the number of published monographs, the high quality of TAPPI Standards, the number of papers appearing monthly in *Tappi*, and the wealth of information that can be found in such other published material as the Routine Control Methods and Technical Information Sheets.

Participation in these committee programs is open to any association member whose experience may contribute to the committee's work. Volunteers feel a deep satisfaction in having a share in furthering the industry's technology. Furthermore, they increase their own knowledge through association with other TAPPI members well versed in specific subjects.

The appointment of any member to a position on a technical committee assumes his willingness to give his personal time to the work of the committee. A member who is interested in obtaining a committee assignment should first seek clearance from his employer and then make his wishes known to the technical secretary of the association staff. His expression of interest will be transmitted to the appropriate committee chairman.

Information regarding the scope of each technical committee is provided in the association yearbook.

Functional Conferences

Several of the technical divisions and committees hold functional conferences at various times during the year. These conferences are devoted to specific subjects and are usually held in different cities each year. The programs of the conferences are usually of great interest to many local section members.

Local sections can participate in functional conferences by acting as host and staffing the local arrangements committee. The benefits of such cooperation include creation of interest in TAPPI's technical committee work, excellent publicity for the section, and stimulation of nonmembers' interest in joining the association and the local section.

Local sections interested in acting as the host to a functional conference should make their desire known to the technical secretary at the association office.

Annual Meeting of the Association

Each February the association holds its annual meeting in New York. Local section members are always welcome to attend. Announcements of the dates of this meeting and the planned program are publicized well in advance in *Tappi* and other trade journals.

At this meeting many of the technical committees and divisions hold technical sessions at which papers are presented. Also, at this time the joint advisory council meets, and the association officers report to the membership on plans for the ensuing year.

APPENDIX

Annual Progress Report

_____ Section of TAPPI Date _____

Membership _____ _____ _____

TAPPI Affiliate Total

Meeting Summaries

First Meeting _____ _____ _____

Date Location Attendance

Principal subject: _____

Speaker(s): _____

Remarks: _____

Secondary features: _____

Remarks: _____

How could have been improved: _____

Second Meeting _____ _____ _____

Date Location Attendance

Principal Subject: _____

Speaker(s): _____

Remarks: _____

Secondary features: _____

Remarks: _____

How could have been improved: _____

(Form provides space for summaries of nine meetings.)

Brief summary of plans for coming season:

The elected officers for the coming year are:

Chairman _____

First vice-chairman _____

Second vice-chairman _____

Secretary _____

Treasurer _____

Executive Committee _____

_____

Program chairman _____

Mailing address of chairman _____

_____

Mailing address of secretary _____

_____

Report given by _____

Date _____

Annual Financial Report of _____ **Section**

Cash on Hand (Date)	
Income for year	
Rebate from TAPPI	
Local dues from National TAPPI members	
Local dues from TAPPI nonmembers (Local affiliates)	
Income from meetings and dinners	
Income from other sources (specify)	
Total	
Expenses for year	
Dinners and other meetings costs	
Postage	
Meeting notices	
Printing, stationery, and mimeographing	
Speakers' expenses	
Office expenses	
Other expenses	
Awards	
Total	
Cash on hand (Date)	
Special funds	

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advantage
does the

AIR CAP®

bring to
papermakers?

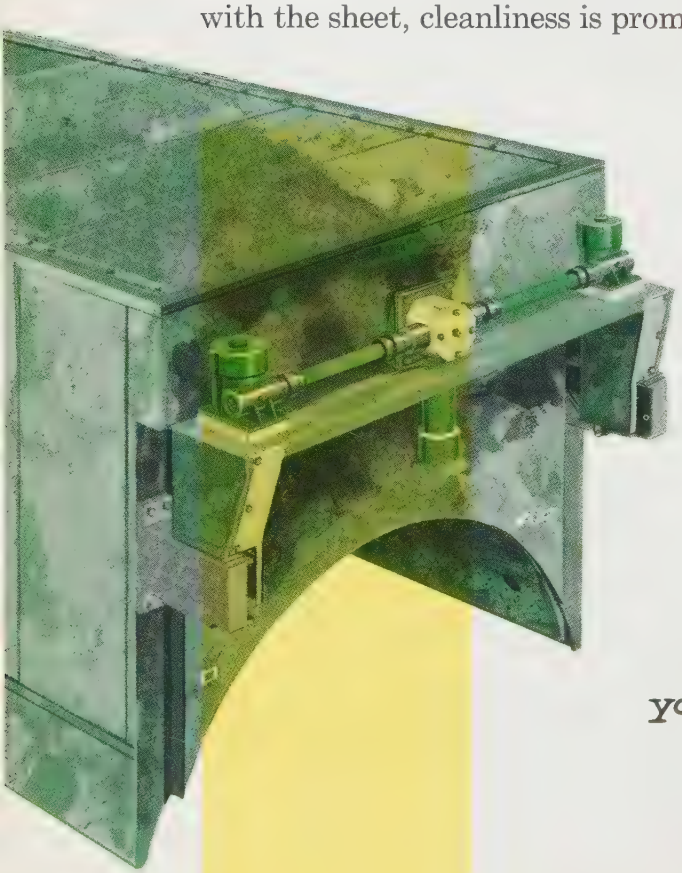
for answer, please turn page

Beloit AIR CAP®* controls and improves board and paper drying

The Beloit Air Cap couples the drying potential of high-velocity air and a design of high efficiency. Concentrated drying capacity is combined with minimum heat and power requirements and a high degree of flexibility.

The streamlined design is of very practical significance. Beloit design minimizes the possibility of interference with the sheet, cleanliness is promoted, and freedom from distortion is assured.

Cross machine correction can be provided. Beloit's arrangement has proved most effective in maintaining uniform moisture content for coating or at the reel. A Beloit representative will be happy to analyze the papermaking and economic possibilities of applications on your machine and discuss all details involved.



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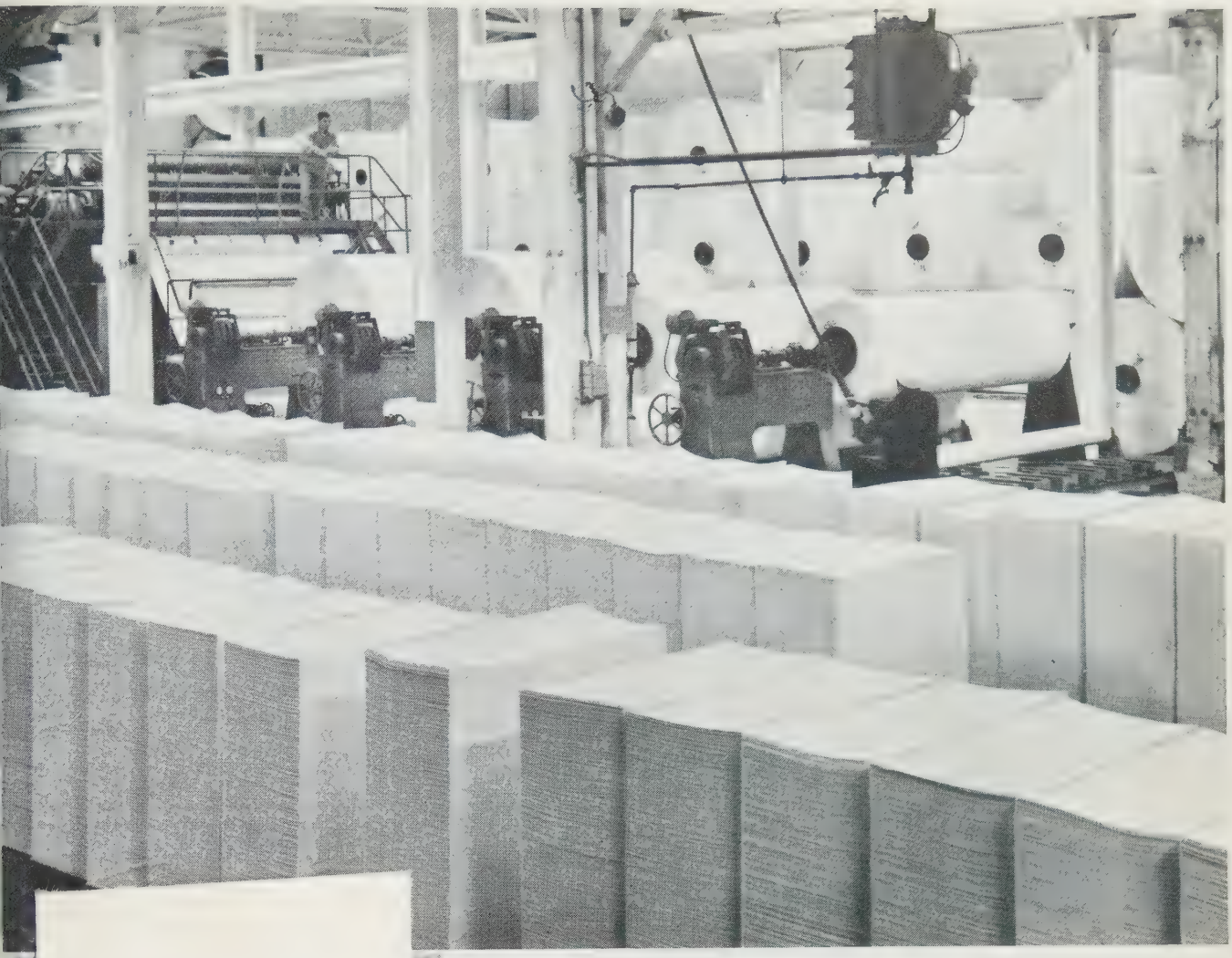

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Write or telephone for your free samples and complete data.

product

Even though Rayonier produces the world's most complete line of pulps and constantly strives to anticipate your market requirements, there's no complacency at Rayonier about product superiority.

Instead we work to strengthen your competitive position with pulps of increasing qualities of strength, opacity, brightness and formation. For we have a long-term commitment with the paper industry: to supply you with the truly great pulps at realistic prices—like Georgianier, another rewarding opportunity for the papermaker.

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GREAT PAPER-MAKING PULPS

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World's Most Complete Line of Paper-Making Pulps: *Western hemlock bleached sulfites; western softwood bleached sulfates; western red cedar bleached sulfates; southern pine bleached sulfates; southern hardwood bleached sulfates; southern pine bleached sulfites.*

Relative Toxicity of Biostatic Agents Suggested for Use in the Pulp and Paper Industry—1960 Supplement

J. H. CONKEY and JOHN A. CARLSON

The data of the screening tests on biostatic agents completed during the past year, continuing the biological research program, sponsored by the American Pulp & Paper Association, are presented. The agent, active ingredient, manufacturer, and inhibiting concentration are given.

THE Biological Control Committee of the American Paper and Pulp Association sponsors at The Institute of Paper Chemistry, as a part of its general program of biological research, a laboratory investigation of the relative toxicity of various biostatic materials offered to the pulp and paper industry. This program was initiated in 1941 for the purpose of providing the industry with comparative toxicity data on commercially available slime-control agents. The program has since been extended to cover materials suggested for uses other than slime control and certain experimental materials believed to be of potential value in our area.

A policy has been established by the Biological Control Committee of publishing a complete review of the data obtained under this program at 5-yr. intervals with current work presented as yearly supplements. This report presents the data of the screening tests completed during the past year and is the second supplement to the review report published in 1958 (*1*). A previo supplement was published in 1959 (*2*).

The laboratory method used to determine the relati toxicity of a test material may be found in the 19 review report (*1*). Briefly, it is an agar-Petri pla procedure using as test organisms *Aerobacter aerogene Bacillus mycoides*, *Aspergillus niger*, and *Penicilliu expansum*. The 27 materials covered in this repo were obtained directly from their suppliers or we sent to us by pulp or paper mill personnel desiring i formation regarding their toxicity. The active ingred ents and the suppliers of the materials are listed in Tab I and the inhibiting concentrations found toward t four test organisms are presented in Table II.

It should be kept in mind that the laboratory pr cedures used in obtaining these data are limited by t fact that the test conditions differ greatly from tho encountered in industrial applications. The inhibiti concentrations serve only as an index to the biologi activity of the material and, therefore, to obtain a m critical evaluation of a material it should be re-examin under conditions which more closely approximate tho of actual use.

For those interested in submitting materials for tes ing under this program, the committee will accept f evaluation those materials offered to the pulp and pap industry for slime control and the preservation of pul

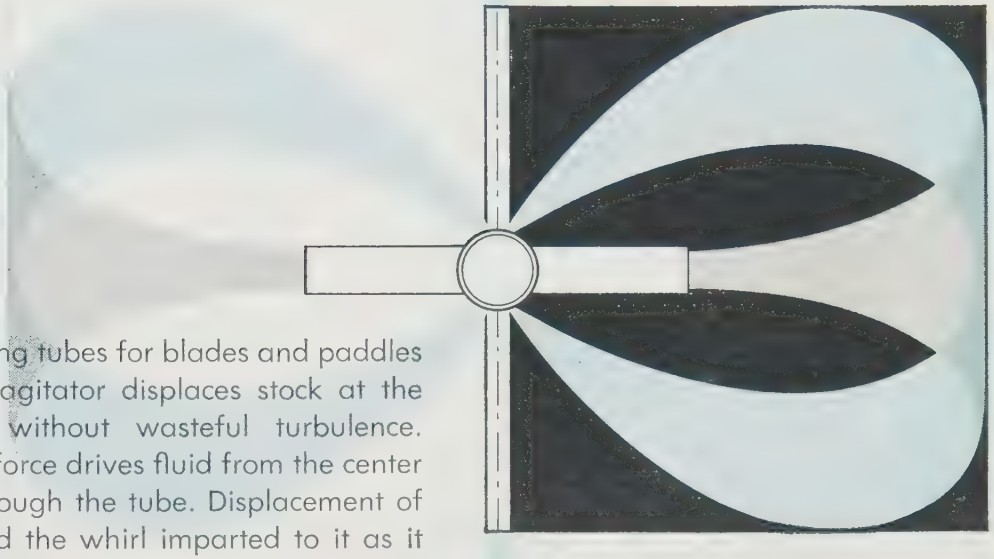
J. H. CONKEY, Research Aide, and JOHN A. CARLSON, Research Aide, The Institute of Paper Chemistry, Appleton, Wis.

Table I. Active Ingredients and Suppliers of Test Materials

Biostatic agent	*Active ingredients*	*Supplier*
AMA-A	Amine methanearsonate	Ansul Chemical Co.
AMA-S-12	Amine methanearsonate	Ansul Chemical Co.
AMA-S-81	Amine methanearsonate	Ansul Chemical Co.
5-Amino-5-ethyl-2-(3,4-dichloro-phenyl)-1,3-dioxane		Commercial Solvents Corp.
5-Amino-5-methyl-1,3-bis-(2-ethyl-hexyl) hexahydropyrimidine		Commercial Solvents Corp.
Amoban	Diammonium ethylene bis dithiocarbamate	Roberts Chemicals, Inc.
Amoban M	Diammonium ethylene bis dithiocarbamate-dimorpholine salt	Roberts Chemicals, Inc.
Amoban P	Diammonium ethylene bis dithiocarbamate-piperazine salt	Roberts Chemicals, Inc.
Amoban T	Diammonium ethylene bis dithiocarbamate-di-triethanolamine salt	Roberts Chemicals, Inc.
Anti-slime A-42	Methoxy ethyl mercuric chloride	Prochim S.A.
Anti-slime S-42	Methoxy ethyl mercuric chloride	Prochim S.A.
Chemocide SAS	Sodium salicylanilide	Chemo Puro Mfg. Corp.
Dioxcide	Chlorine dioxide	Chemical Research Laboratories of America, In
HA	*p*-Methoxyphenol	Ansul Chemical Co.
HQA	8-Hydroxyquinolinium arsanilate	Ansul Chemical Co.
HQC	8-Hydroxyquinolinium cacodylate	Ansul Chemical Co.
HQMA	8-Hydroxyquinolinium methane-arsonate	Ansul Chemical Co.
HQMA-S	8-Hydroxyquinolinium methane-arsonate	Ansul Chemical Co.
Key S.C.A.-329	Bis (tributyl tin) oxide	Key Chemicals Corp.
2-Nitrobutyl citrate		Commercial Solvents Corp.
2-Nitro-1-*p*-chlorophenyl-1-butene		Commercial Solvents Corp.
2-Nitro-1-phenylpropene		Commercial Solvents Corp.
2-Nitro-1-phenylpropyl tolyl sulfone		Commercial Solvents Corp.
4-Nitro-3-trifluoromethyl phenol		Maumee Chemical Co.
1-Nitroundecanol		Commercial Solvents Corp.
Para-nitro anisole	*p*-Nitroanisole	Ansul Chemical Co.
Slimacide V-10	Bis-(1,4-bromacetoxy)-2-butene	Vineland Chemical Sales Corp.

From S. W. Hooper: a pump principle for improved stock agitation

Cowan stock agitator provides a better blend with less than half the power



By substituting tubes for blades and paddles the Cowan agitator displaces stock at the tank edge without wasteful turbulence. Centrifugal force drives fluid from the center outward through the tube. Displacement of the fluid and the whirl imparted to it as it leaves the rotating tube combine to produce an agitation that continually moves the entire content back and forth between shaft and walls.

Both the flow through the tube and the power are subject to factors that can be readily calculated for accurate engineering of every separate installation.

It is this precision element in the design that permits measurable full blending with power consumption reduced by more than fifty per cent.

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Table II. Relative Toxicity

Biostatic agent	Inhibiting concentration, p.p.m.			
	Aerobacter aerogenes	*Bacillus mycoides*	*Aspergillus niger*	*Penicillium expansum*
AMA-A	300	200	>3000	>3000
AMA-S-12	300	250	>3000	>3000
AMA-S-81	1500	600	>3000	>3000
5-Amino-5-ethyl-2-(3,4-dichlorophenyl)-1,3-dioxane	350	250	>3000	500
5-Amino-5-methyl-1,3-bis-(2-ethylhexyl) hexahydropyrimidine	150	3	>3000	2500
Amoban	40	6	1500	35
Amoban M	30	6	60	35
Amoban P	30	4	80	40
Amoban T	45	7	95	40
Anti-slime A-42	4	0.5	20	10
Anti-slime S-42	3	0.9	20	9
Chemocide SAS	90	70	80	75
Dioxcide	>3000	2000	>3000	>3000
HA	2500	2000	1500	750
HQA	200	15	400	55
HQC	150	8	400	40
HQMA	75	7	450	55
HQMA-S	250	20	1500	150
Key S.C.A.-329	95	7	35	200
2-Nitrobutyl citrate	150	10	250	150
2-Nitro-1-*p*-chlorophenyl-1-butene	>3000	0.7	75	7
2-Nitro-1-phenylpropene	20	2	50	20
2-Nitro-1-phenylpropyl tolyl sulfone	70	4	>3000	200
4-Nitro-3-trifluoromethyl phenol	25	20	80	50
1-Nitroundecanol	>3000	10	3000	350
Para-nitro anisole	600	650	400	350
Slimacide V-10	150	45	350	100

> = Greater than.

sizing materials, felts, finished papers, etc. Experimental materials which have properties indicating potential usefulness toward microbiological control in the industry are also acceptable; however, the nature of the active ingredient(s) of all materials submitted must be revealed.

LITERATURE CITED

1. Conkey, J. H. and Carlson, John A. Relative toxicity of biostatic agents suggested for use in the pulp and paper industry—1958 review. American Paper and Pulp Association. 21 pp., 1958; *Tappi* 43, No. 10: 12A (Oct., 1960).
2. Conkey, J. H. and Carlson, John A. Relative toxicity of biostatic agents suggested for use in the pulp and paper industry—1959 supplement. American Paper and Pulp Association. 6 pp., 1959; *Tappi* 43, No. 10: 40A (Oct., 1960).

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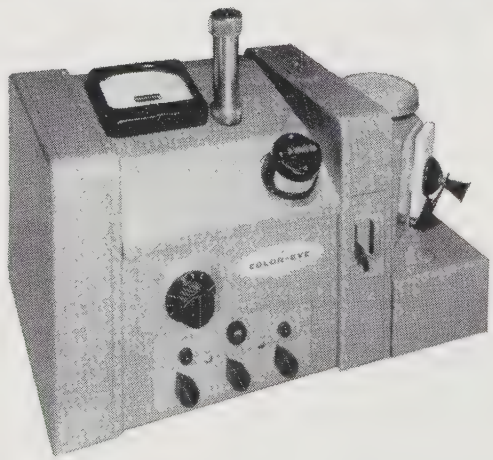

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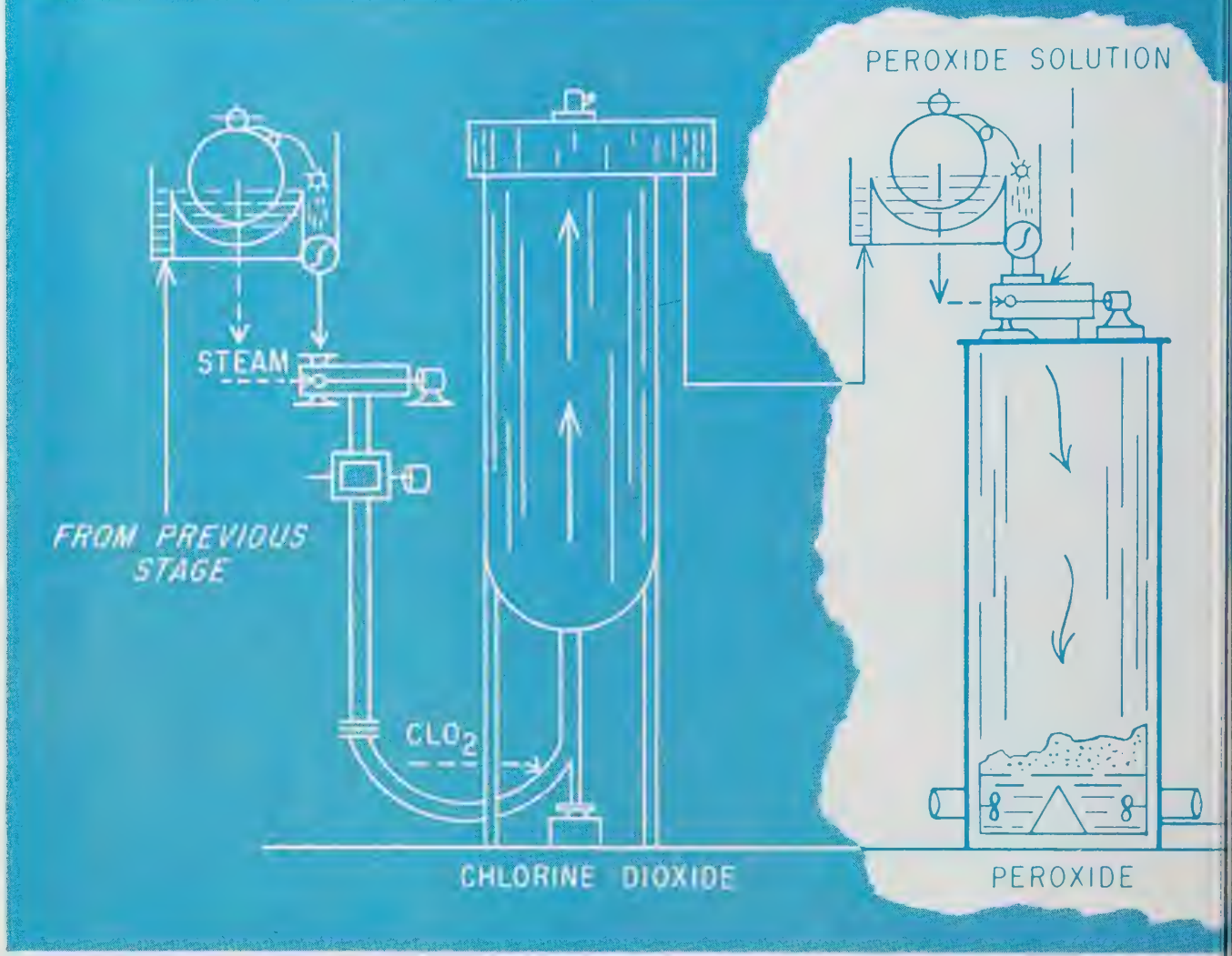

Peroxide may be used as a replacement for caustic soda between two chlorine dioxide stages (as shown above

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With today's market trend demanding higher and higher brightness for kraft pulp, here are two ideas from Du Pont that might prove well worth your thorough investigation.

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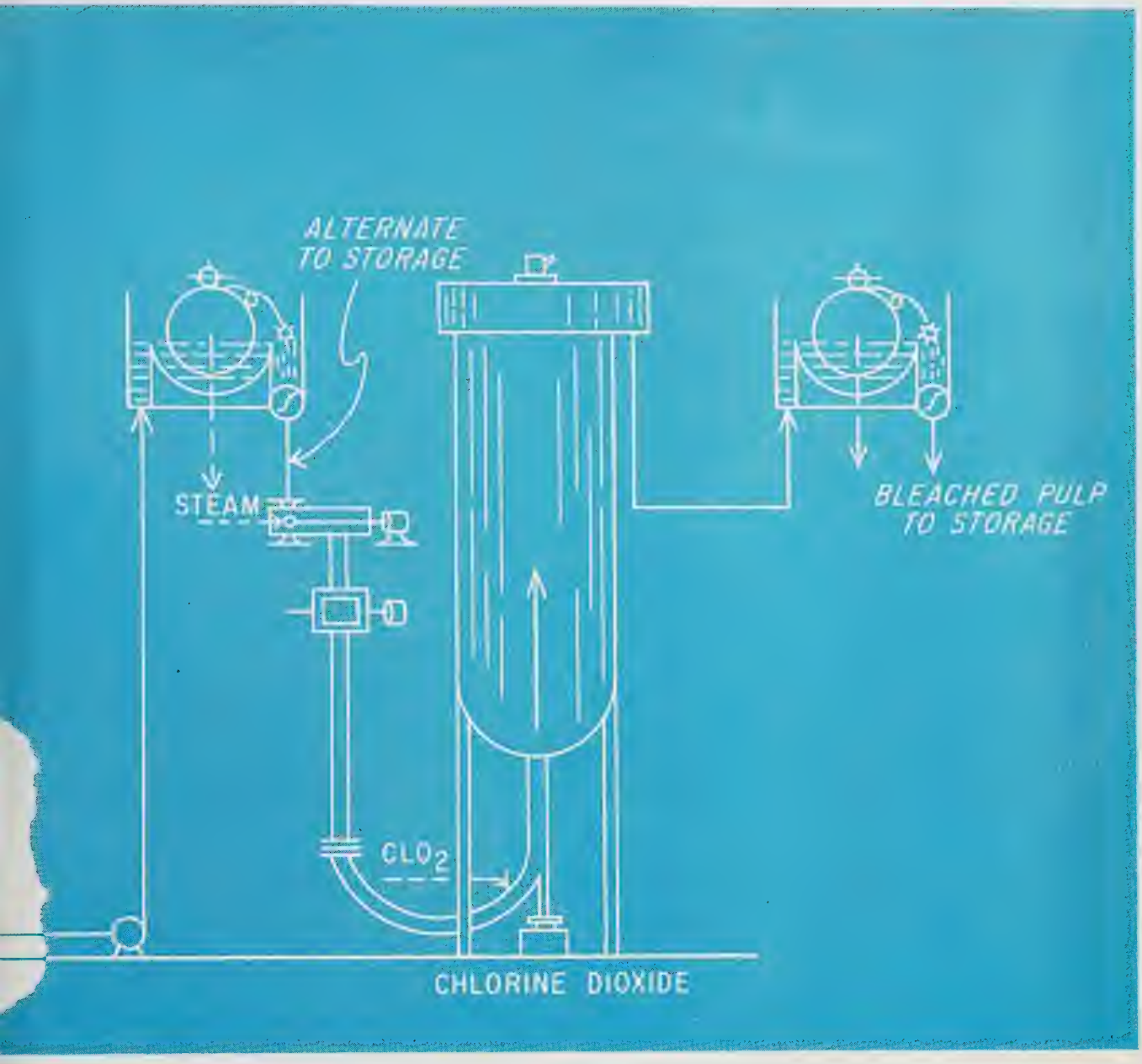

or as a final treatment after a chlorine dioxide treatment, to give you higher pulp brightness.

to increase kraft pulp brightness

for the peroxide-treated pulps, after standard heat reversion tests.

Du Pont peroxides are easy to use and require only a minimum of handling equipment to introduce into your operation. Du Pont technical representatives will be glad to show you what peroxides can do for you and can suggest process layouts (such as the one shown above) to fit into your present plant operation. Contact your nearest representative listed below, or write: Du Pont, Electrochemicals Department, Wilmington 98, Delaware.

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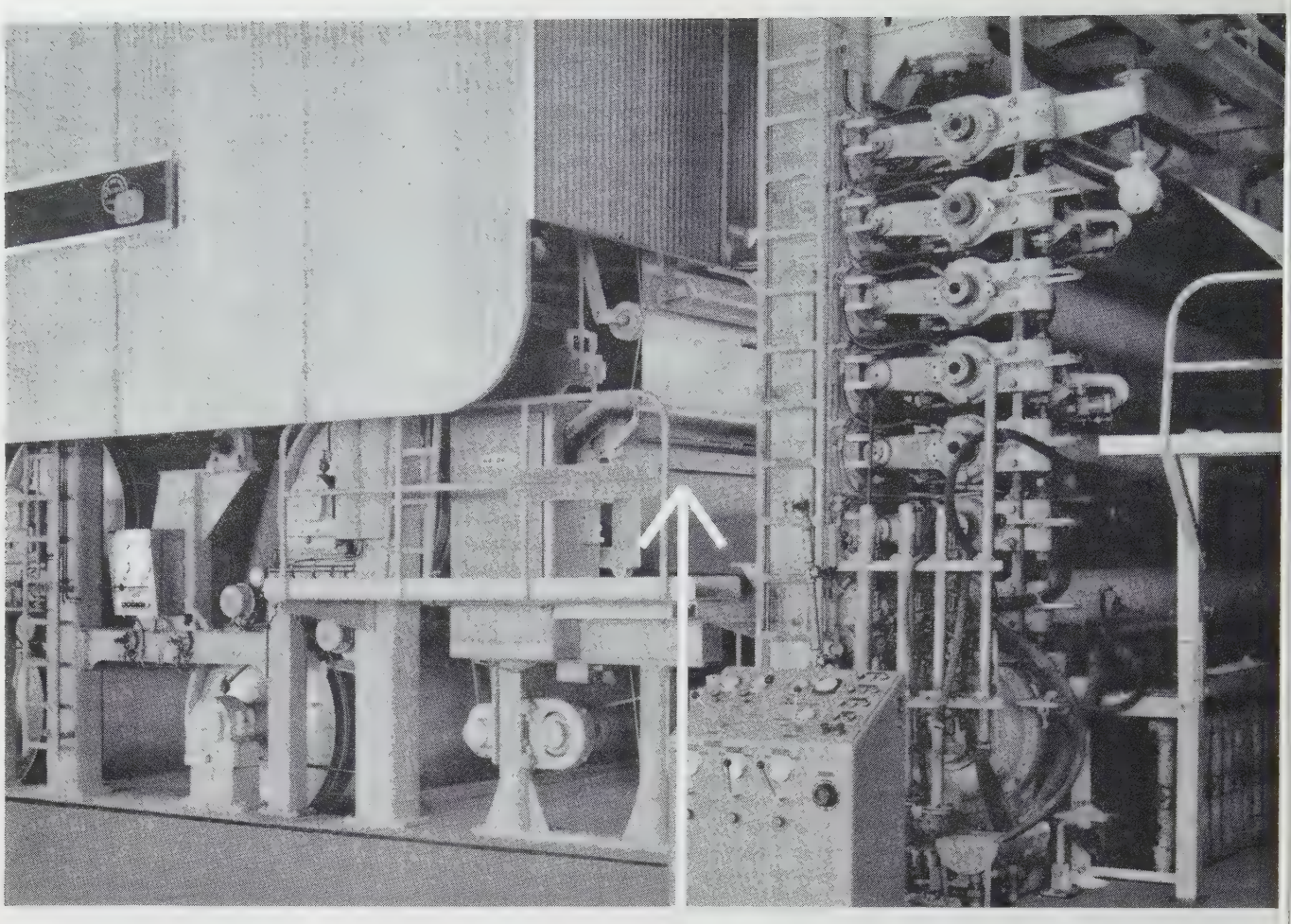

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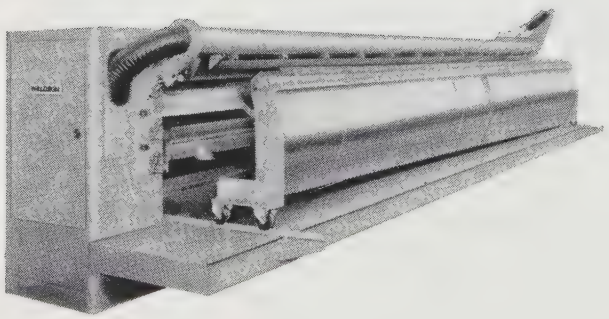

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The competition packages must face today on retailers' shelves leaves no room for anything less than perfection in printing quality.

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Viscosity—RHOPLEX coatings containing up to 60 percent solids can be handled readily at high speeds, provided the binder content is mainly RHOPLEX. Figure I shows effect of RHOPLEX on viscosity.

Figure I

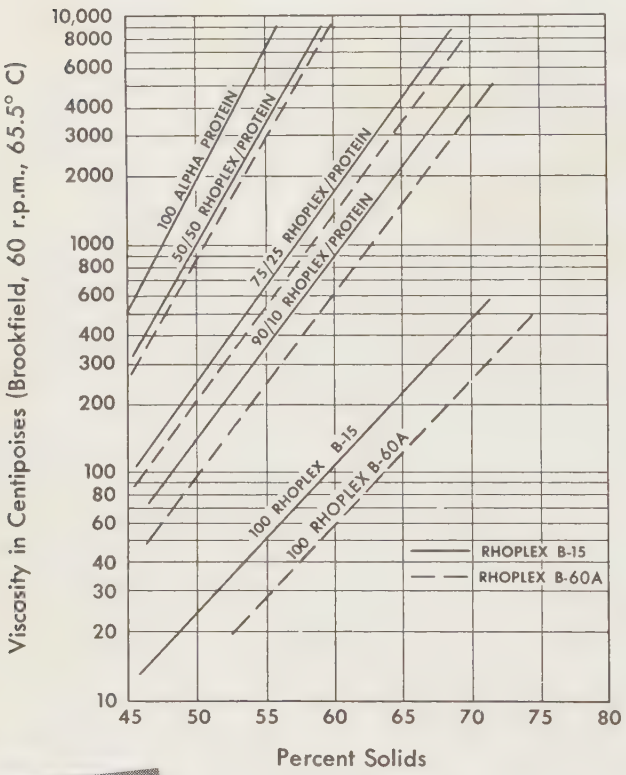

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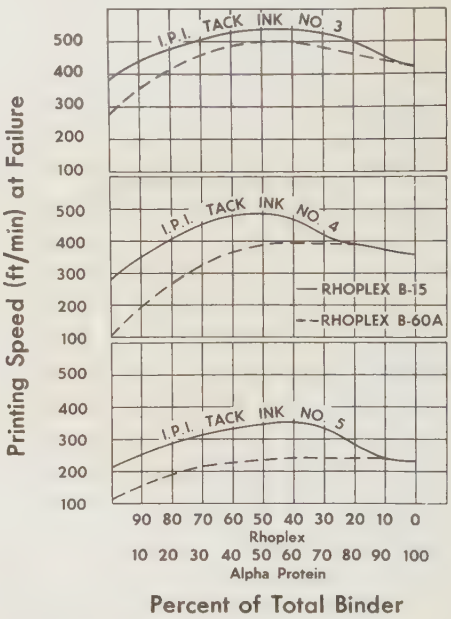
Figure II



Brightness and Gloss—RHOPLEX preserves the high brightness inherent in pigmented coatings. It also produces higher gloss than is possible with natural binders. Unlike natural materials, RHOPLEX is a thermoplastic, has a flow and leveling action under the heat and pressure of the calender rolls.

ROHM & HAAS

PHILADELPHIA 5, PA.

RHOPLEX

THIELE KAOLIN

water-washed, spray-dried COATING CLAYS

- **Controlled Particle Size** • **Excellent Color**
- **Standardized Low Viscosity** • **High Brightness**

Thiele Water-Washed Clays are mined from vast holdings in the heart of Georgia's clay belt, carefully tested and controlled while being processed at Thiele's modern plant. Two spray drying plants assure coating clays that will provide EASIER MAKE-DOWN—IMPROVED HANDLING—LOWER MOISTURE CONTENT—MORE UNIFORMITY.

Write for full information.

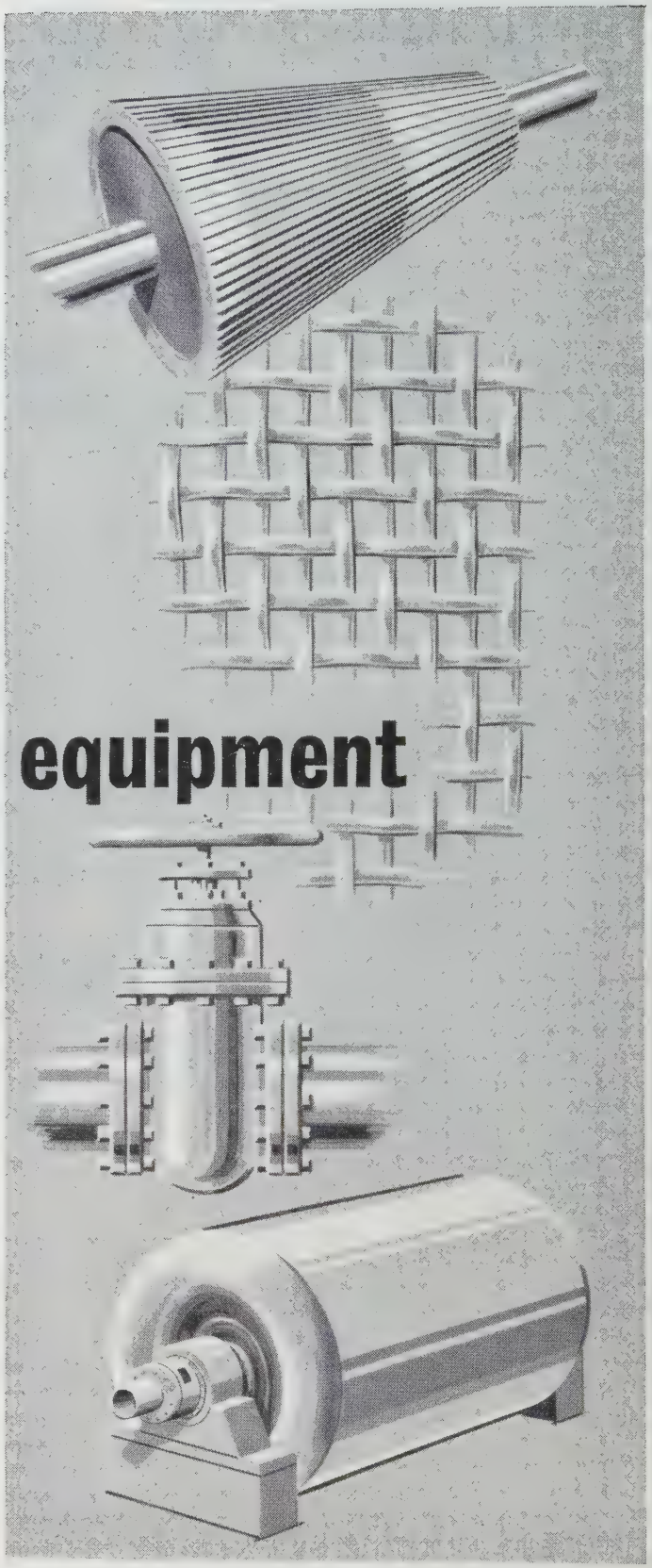
Thiele Kaolin Company

P. O. BOX 270 • SANDERSVILLE, GA.

In Making Wet-Strength Papers–

KYMENE® POLYAMIDE RESINS

are kind to your equipment



Why let acid corrosion eat up your paper stock system? Kymene wet-strength resins 557 and 709 function in neutral or alkaline pH systems and do not need corrosive acid conditions to develop their wet-strength characteristics.

See what Kymene polyamide-epichlorohydrin wet-strength resins can do for you. Contact the nearest Hercules Paper Makers Chemical sales office:

Atlanta, Ga. Milwaukee, Wis.
Holyoke, Mass. New Orleans, La.
Kalamazoo, Mich. Portland, Ore.
Wilmington, Del.

Paper Makers Chemical Department

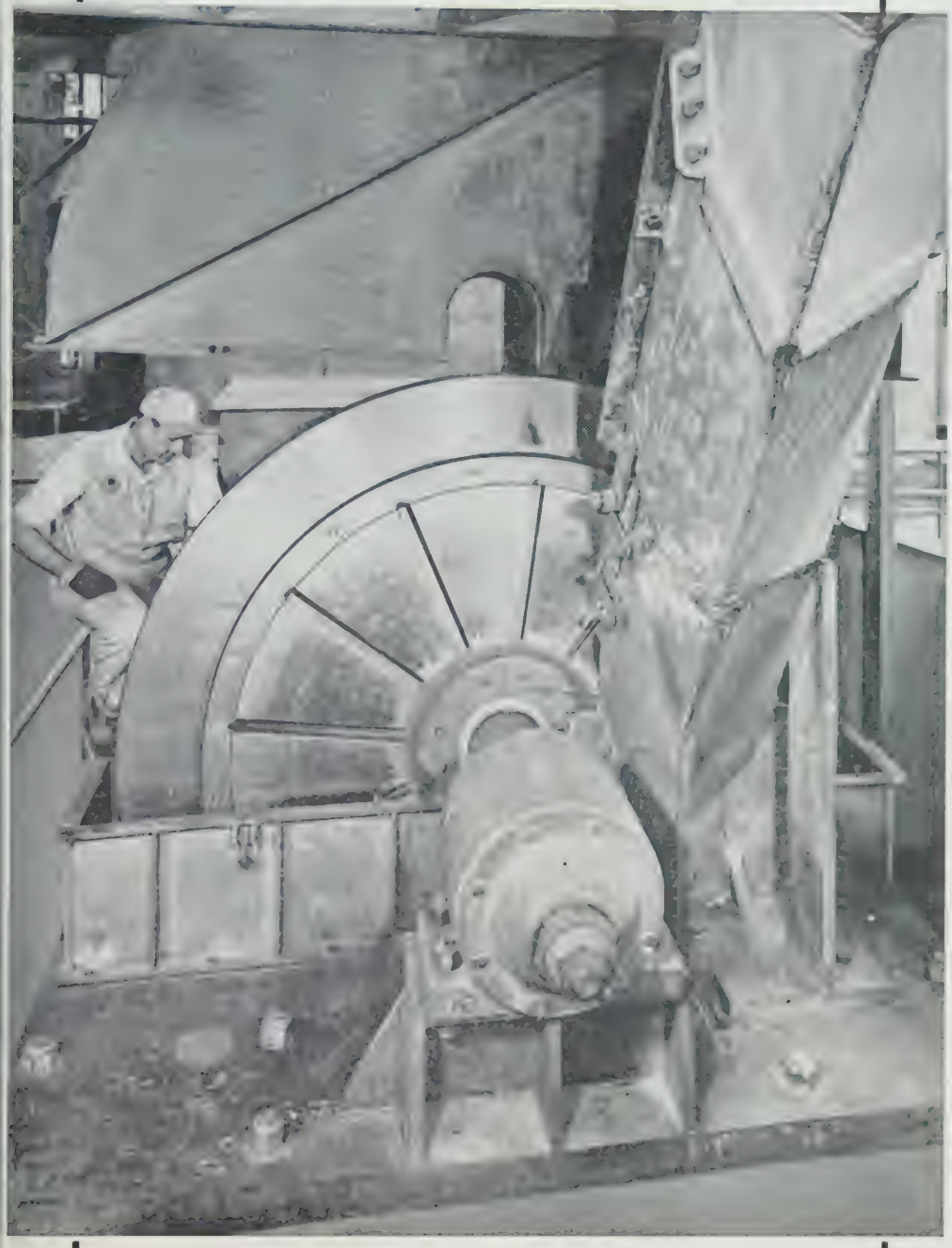
HERCULES POWDER COMPANY

INCORPORATED

Hercules Tower, 910 Market Street, Wilmington 99, Delaware

PP61-3

Carthage-Norman Chippers Give You Less Sawdust — Higher Strength Pulp



With its unique helicoidal disc segments and variable-bevel knives, the Carthage-Norman Chipper produces the highest percentage of "to size" chips. There are fewer compressed or bruised chips and ½% to 1% less sawdust —a feature which can pay for the chipper in one year. Knives wear longer—cost less. Heavy-duty construction results in exceptionally low maintenance costs.

SEND THE COUPON TODAY

CARTHAGE MACHINE CO.
CARTHAGE, NEW YORK

Please send full details showing why a Carthage-Norman Chipper will give me a greater production of uniform, clean-cut, "to size" chips.

Name .....

Firm .....

St. or Rd. .....

City ..... *Zone* ..... *State* .....

D

*Idea submitted by Donald F. Somes, Simpson Lee Paper Co., Lowell, Washington
Photo: Courtesy Convair Div. General Dynamics Corporation

"Reminds me that HAMILTON Felts, too, deliver more tonnage, faster, with fewer stops!"

YOU CAN'T BEAT
Hamilton
FELTS

"Like the new jet airliners,
long-lasting Hamilton Felts
are 'best in the long run.'
All Hamilton Felts are 'water-conditioned'
deliver drier sheets to the drier,
keep your machines running at top speed . . .
longer . . . with fewer stops . . . turning out
more tonnage, less broke, more profits.

If one of our 'standard 300' modern,
technically proven styles won't solve
your needs, we will be happy
to design a Hamilton Felt that will.
Just ask your Hamilton Felts Service Salesman."

*WIN . . . *A NEW Shakespeare Spincast Fishing Outfit!*

"What famous place reminds you of Hamilton Felts? Tell us why in a few words; sign your name and address and name of company. Each idea from a U.S. papermaker that we use wins a new 1961 model Shakespeare Spincast Rod and Reel—FREE! When identical winning ideas are submitted by 2 or more papermakers, the one with the earliest postmark will be considered the winner. Every U.S. papermaker *entrant* receives a famous Rex Spoon fishing lure—FREE. Send me your suggestion—today. Ham Feltz, Dept. T, 612 First National Bank Bldg., Cincinnati 2, Ohio."

SHULER & BENNINGHOFEN, HAMILTON, OHIO

RETENTION:

In a zoo it means safety...to a paper mill

it means **SAVINGS!**

***A significant increase in percentage of filler retained*—that's the DOLLAR-SAVING experience of more and more mills as a direct result of using a DARLING glue solution as a wet end additive.**

We'd like to work with you in determining what can be accomplished in your mill. The entire cost is on us, so you've nothing to lose—everything to gain. You can make arrangements through your DARLING sales representative. Or write or call us direct.

DARLING & COMPANY
GLUE DIVISION
4201 South Ashland Avenue • Chicago 9, Illinois

DARLING'S
improved BONE GLUE

available with CENTER WIND ATTACHMENT

VALLEY IRON WORKS CORPORATION

APPLETON, WISCONSIN

a subsidiary of Allis-Chalmers Manufacturing Company

West Coast Representative: E. A. Berry, P.O. Box 958, Longview, Washington

Canadian Representative: Pulp and Paper Mill Association Ltd., P.O. Box 850, Station "O", Montreal 9, Quebec

VALLEY

Lightest in color... best stability! Test for yourself the properties of ALWAX* and WAXINE® sizes, the products of Cyanamid, America's oldest—and largest—producers of **Wax Sizes.** See for yourself that they offer the lightest color available anywhere... and the best stability. Other advantages—? Plenty! The most complete line... to assure you of the exact **Wax Size** for your particular need. Compatibility with other paper-making chemicals. Properties that produce paper with lower water absorption, smoother surface, less curl, greater ink resistance, improved lactic-acid resistance. Cyanamid **Wax Sizes** can be used with rosin sizes to increase sizing efficiency, lessen the quantities needed, and create major production savings. Call your Cyanamid salesman for complete technical information to help you select the right **Wax Size** from the widest, lightest line of sizes available today.

*TRADE MARK

CYANAMID

AMERICAN CYANAMID COMPANY • PAPER CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, N. Y.

Why have so many installations of chemical recovery units (in the past five years) been equipped with Bailey instruments and controls?

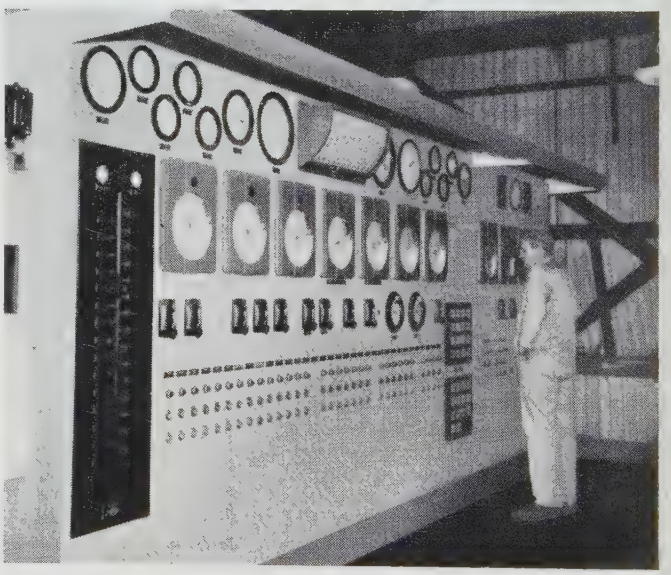
Bailey assures reliable and continuous operation with a control system engineered specifically for the chemical recovery process.

Every Bailey installation gives top performance. It's the reason for Bailey's long and prominent association with chemical recovery . . . and it's why you'll find Bailey instruments controlling virtually every process within many pulp and paper mills.

Bailey starts with sound engineering and economic evaluation of your needs . . . an evaluation based on more than 40 years' experience, kept fresh by a national network of engineers in constant contact with your industry.

Then the selection of the *right* system . . . selection made simple by a complete line of equipment . . . from conventional instruments through sophisticated data processing systems.

That's the Bailey way. Put this logic, capability and performance to work on any process control problem you have. Call on the Bailey District Office or your nearby Resident Engineer. Or, write direct.



In Oregon—maximum economy, minimum maintenance since 1958; Bailey control center for chemical recovery unit at Georgia-Pacific Paper Co., Toledo, Oregon. Evaporator system (right) is also operated from this Bailey center.

P152-1

PULP AND PAPER DIVISION

BAILEY METER COMPANY

1077 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

KÄLLE

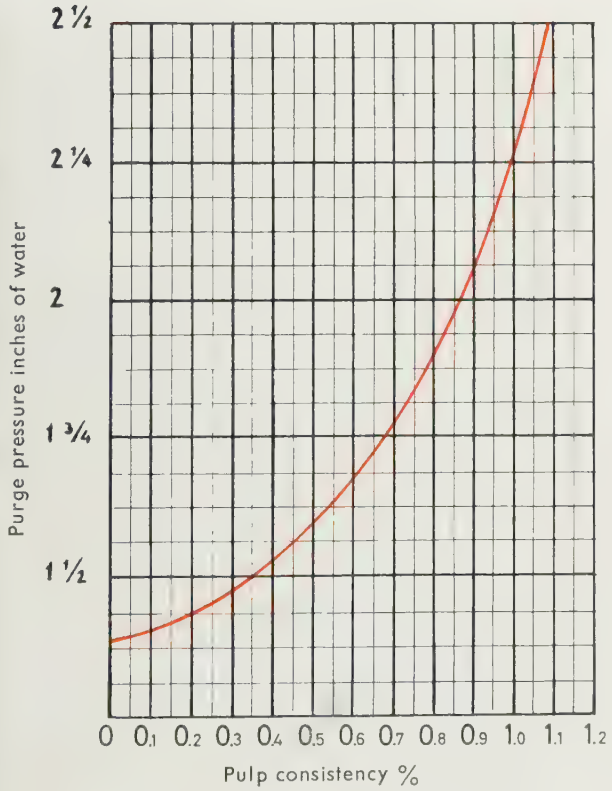
"floating disc"

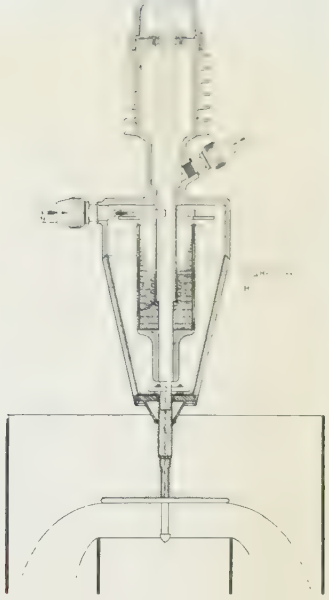
FOR LOW PULP CONSISTENCY CONTROL
0 — 1,5 %

A brilliant solution of an extremely difficult problem

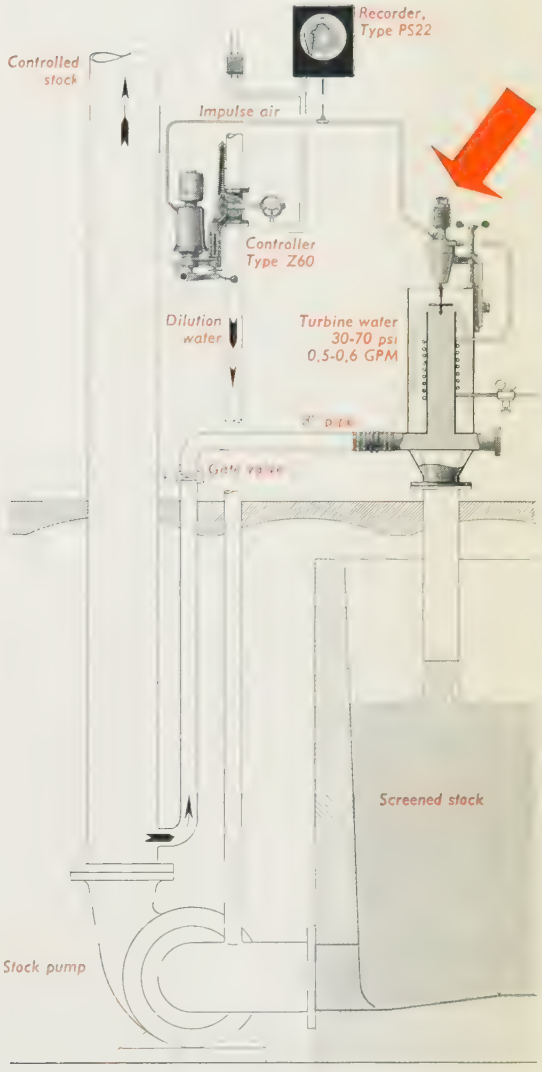
CONSISTENCY CONTROL
by water turbine drive provides the following unsurpassed advantages:

1. **Turbine-water paraboloid,** formed by the rotating vessel, in conjunction with bubble-pipe gives a precise, simple and stable impulse. Purge pressure varies as a quadratic function of pulp consistency to insure high sensitivity.
2. **Turbine-water** temperature may be adjusted to that of stock, to fully compensate for temperature-dependent variations on stock friction properties.
3. **Turbine-water pressure** easily adjustable for various consistency ranges.
4. **Turbine-water** provides continuous rinsing of the sensing element.





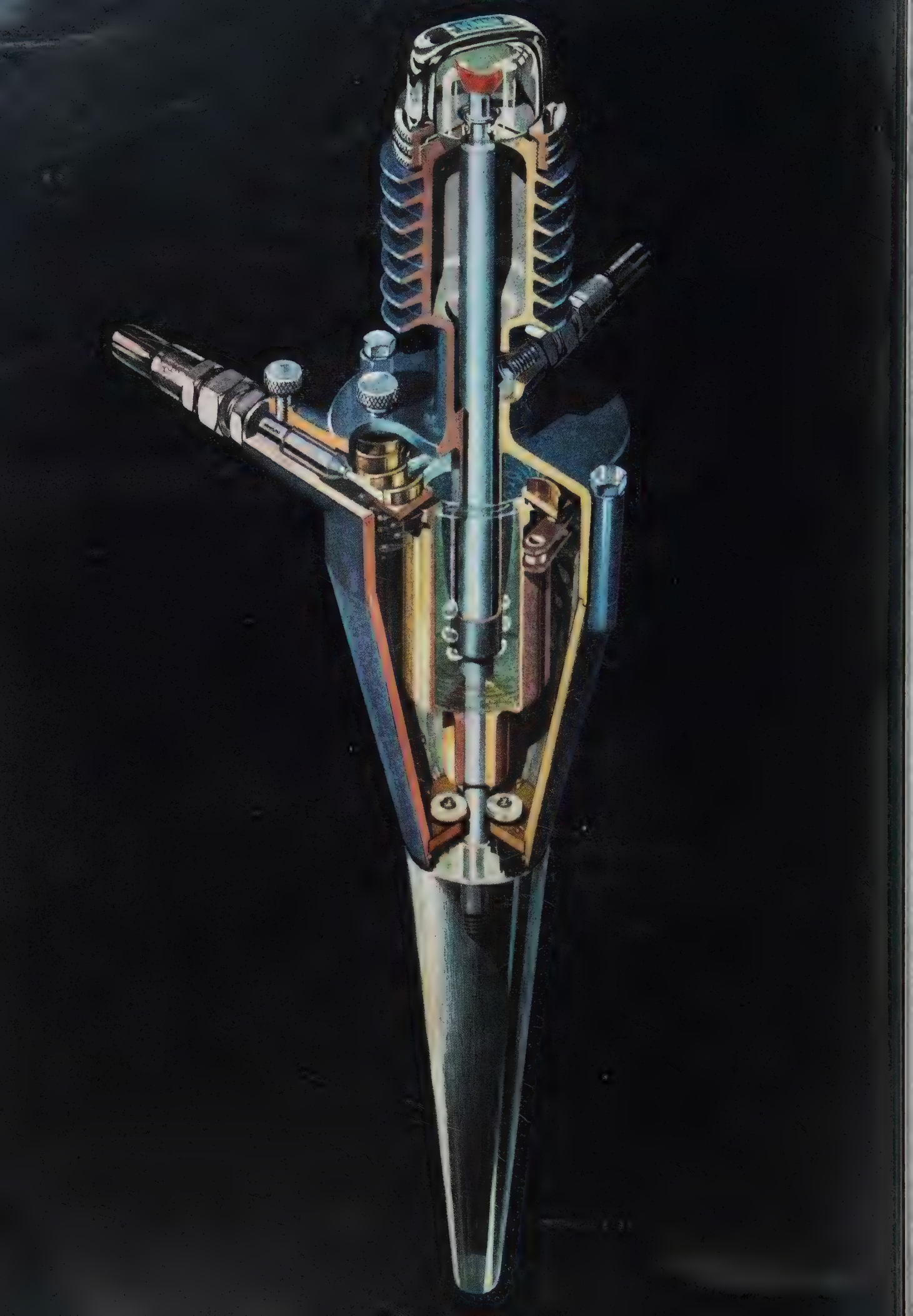
Källe Consistency Regulator, Type K22S "Floating disc", controls and records pulp consistencies accurately from 0 to 1,5 %. Accuracy better than ± 0,05 % of consistency. For higher pulp consistencies, 1,5—6 %, Type K22K with "Conical" sensing elemnt may be used. See picture on next page.

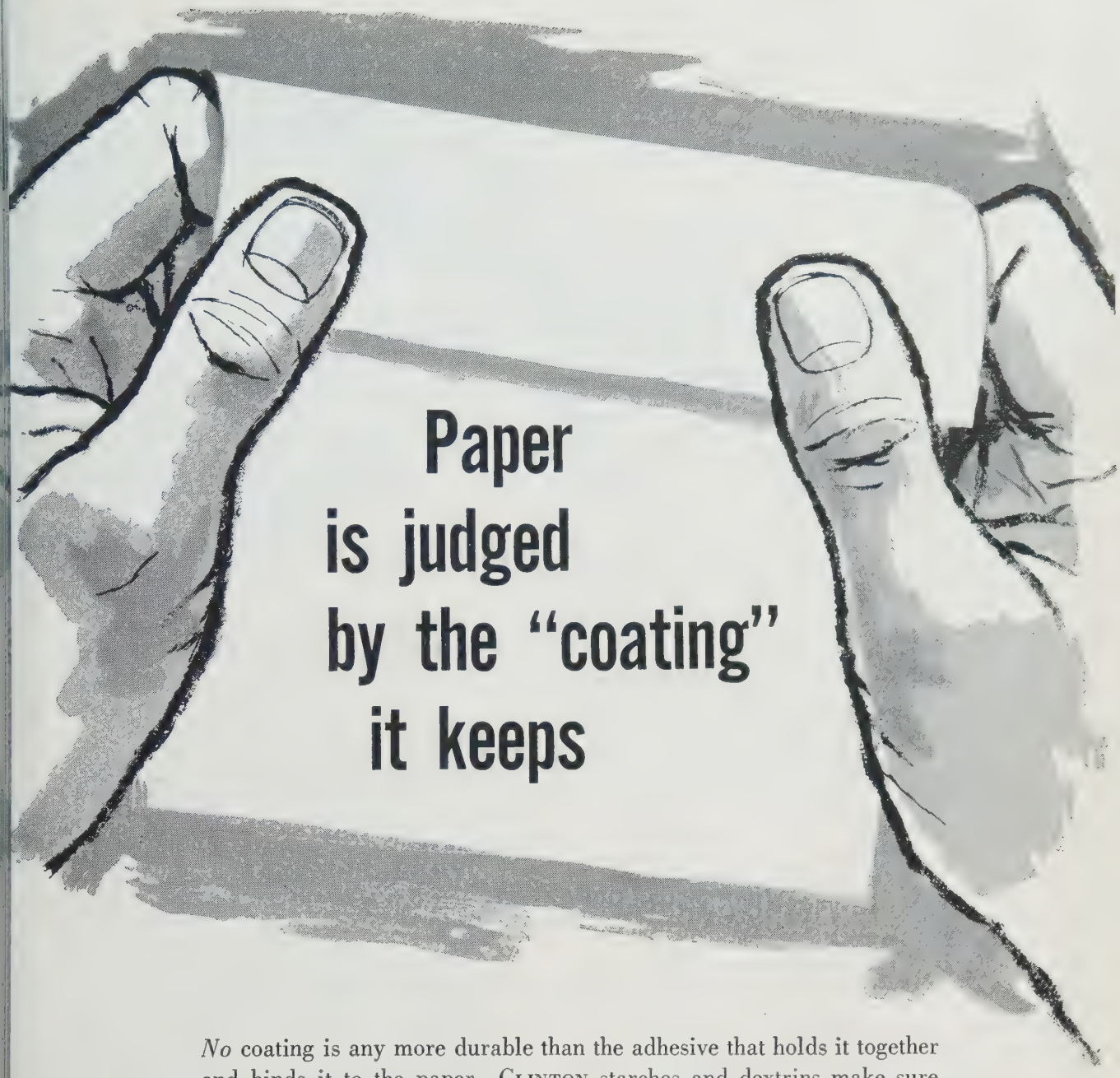


AKTIEBOLAGET KÄLLE-REGULATORER · SÄFFLE · SWEDEN

Representative for US: Rosenblad Corp., 1270 Sixth Ave. New York 20, N. Y.

Cable address: Calospiral Telephone: Circle 7-8462





Paper is judged by the "coating" it keeps

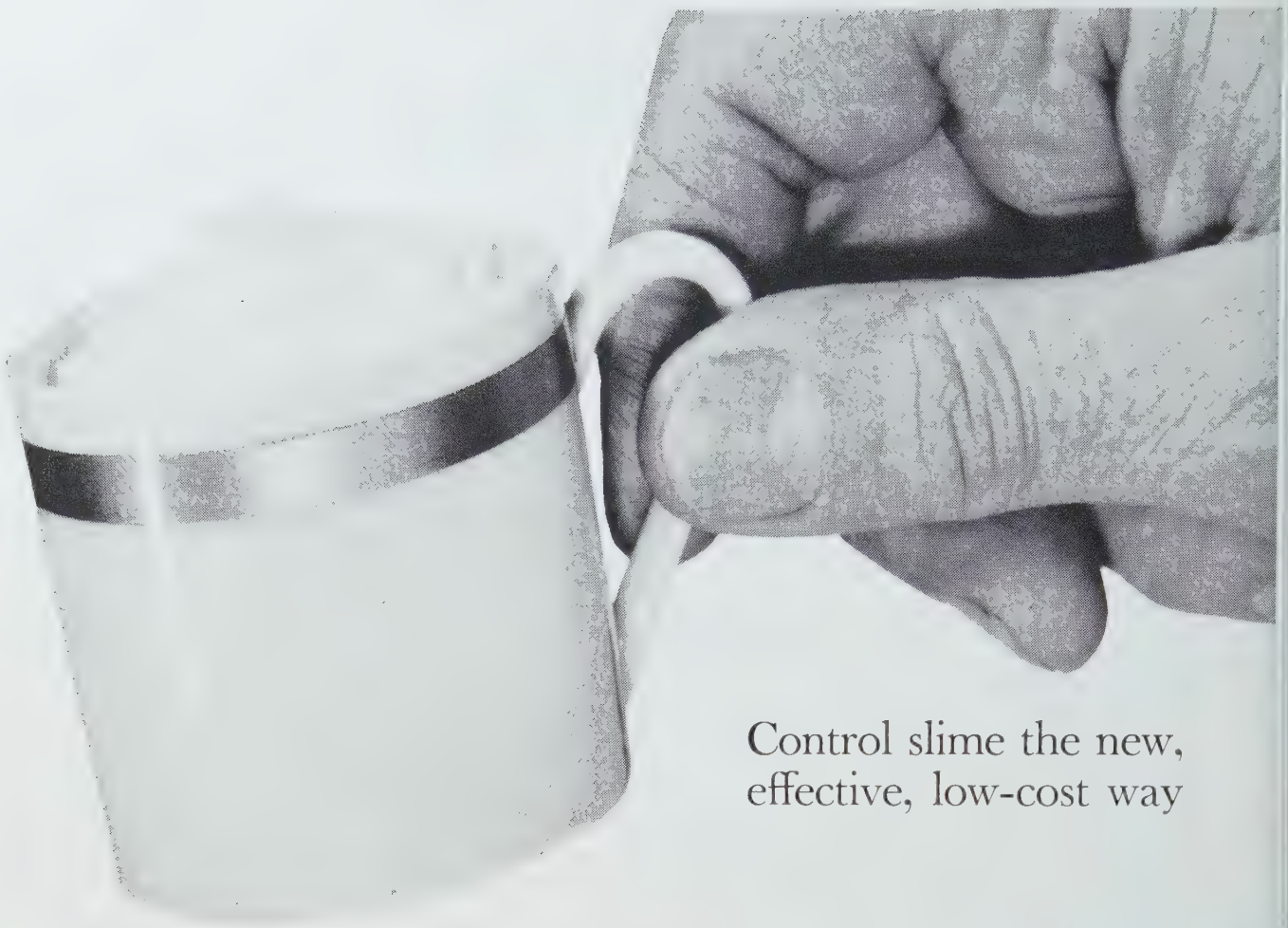
No coating is any more durable than the adhesive that holds it together and binds it to the paper. CLINTON starches and dextrins make sure that your coated stock has a uniform finish free from "skips." Used as a clay coating or as a size, CLINEO starches add a high degree of strength and gloss printing quality to gloss surfaces. CLINCAL starches — containing their own lubricants — improve printability and control curl. Both starches are available in many varieties. For quality that makes a lasting impression on customers and prospects, use CLINTON coating starches.

Technical service always available

CLINTON CORN PROCESSING COMPANY

CLINTON

CLINTON, IOWA



Control slime the new, effective, low-cost way

Just this much C2® slimicide for a ton of pulp!

- Newsprint
- Unbleached, semi-bleached and bleached kraft
- Food and paper board
- Printing and book papers

EFFECTIVE. Extensive mill use proves conclusively that C2, the new Mathieson slimicide, is the most effective product for acidic white water systems. Only ¼ pound of C2 per ton of pulp (often even less) is a common dosage rate for rapid, sustained control. Actual cost per ton: about 10-20¢. Resultant action: continuous generation of chlorine dioxide throughout the white water system . . . a distinct advantage over other slimicides which function only near point of application.

Other C2 advantages: no foaming at the head box . . . will not darken pulp . . . will not affect dyes at recommended dosage rates.

EASY-TO-USE. C2 is readily soluble in water and is non-corrosive to equipment.

C2 is shipped in highly-soluble, dry-flake form in quantities from one-pound samples to 100-pound drums in truckloads and carloads. Also, 50% solution is supplied in tank cars and trucks.

FDA CLEARANCE. C2 is our trademark for sodium chlorite. The Food And Drug Administration has expressed the opinion that this chemical is not a food additive when used as a slimicide as it cannot reasonably be expected to become a component of food through this use.

See C2 work in your mill—call for a demonstration.

Olin Mathieson, Baltimore 3, Maryland

CHEMICALS DIVISION Olin

164

In Argentina as well as in the U.S.A. . . .

papermakers use and like

RIEGEL PULPS

CHLORINE DIOXIDE BLEACHED

ALBACEL
Bleached Softwood

MIRACEL
Prehydrated Bleached Softwood

ASTRACEL
Bleached Hardwood

HYDRACEL
Prehydrated Bleached Hardwood

Throughout the free world, papermakers use and like Riegel Pulps . . . paper-grade pulps that provide the right balance of all important qualities . . . brightness, cleanliness, strength, formability and proper beating characteristics.

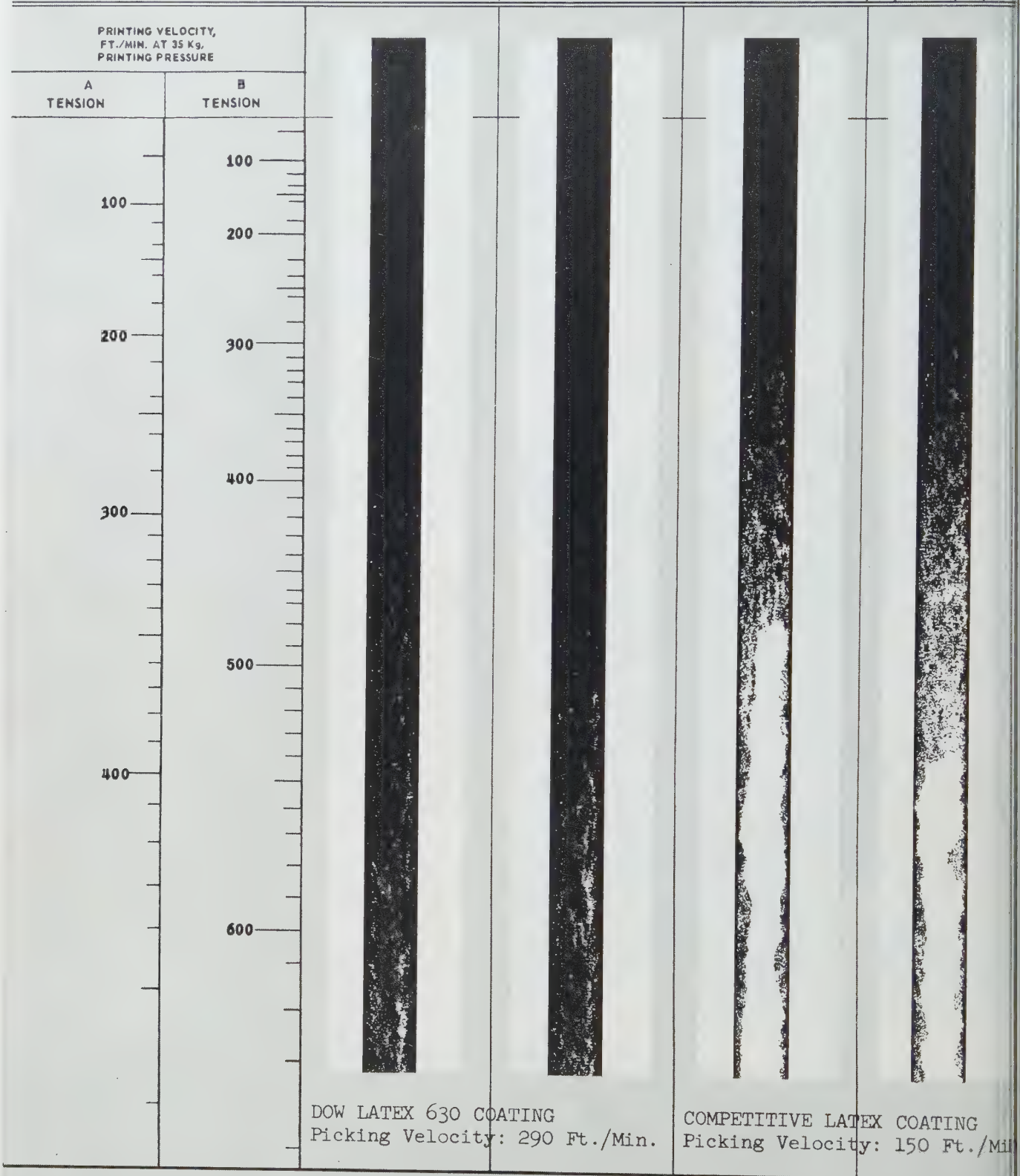
BALANCED PAPER-GRADE PULPS . . .
Created *BY* Papermakers *FOR* Papermakers

Riegel Paper Corporation, 260 Madison Ave., N.Y.C. 16.

VELOCITY CHART FOR IGT PRINTABILITY TESTER

INK USED IPI NO. 6

SPRING TENSION USED [X] A [ ] B



PROVEN commercially... greater pick resistance with DOW LATEX 630

The velocity chart, left, for IGT Printability Tester provides proof of the greatly superior pick resistance of new Dow Latex 630. Here, laboratory test data are reported on the relative printability of commercially coated papers.

The two strips on the right coated with a competitive latex represent the performance of the "standard" grade. The two strips on the left represent the performance of that grade with Dow Latex 630 replacing the competitive latex in the coating.

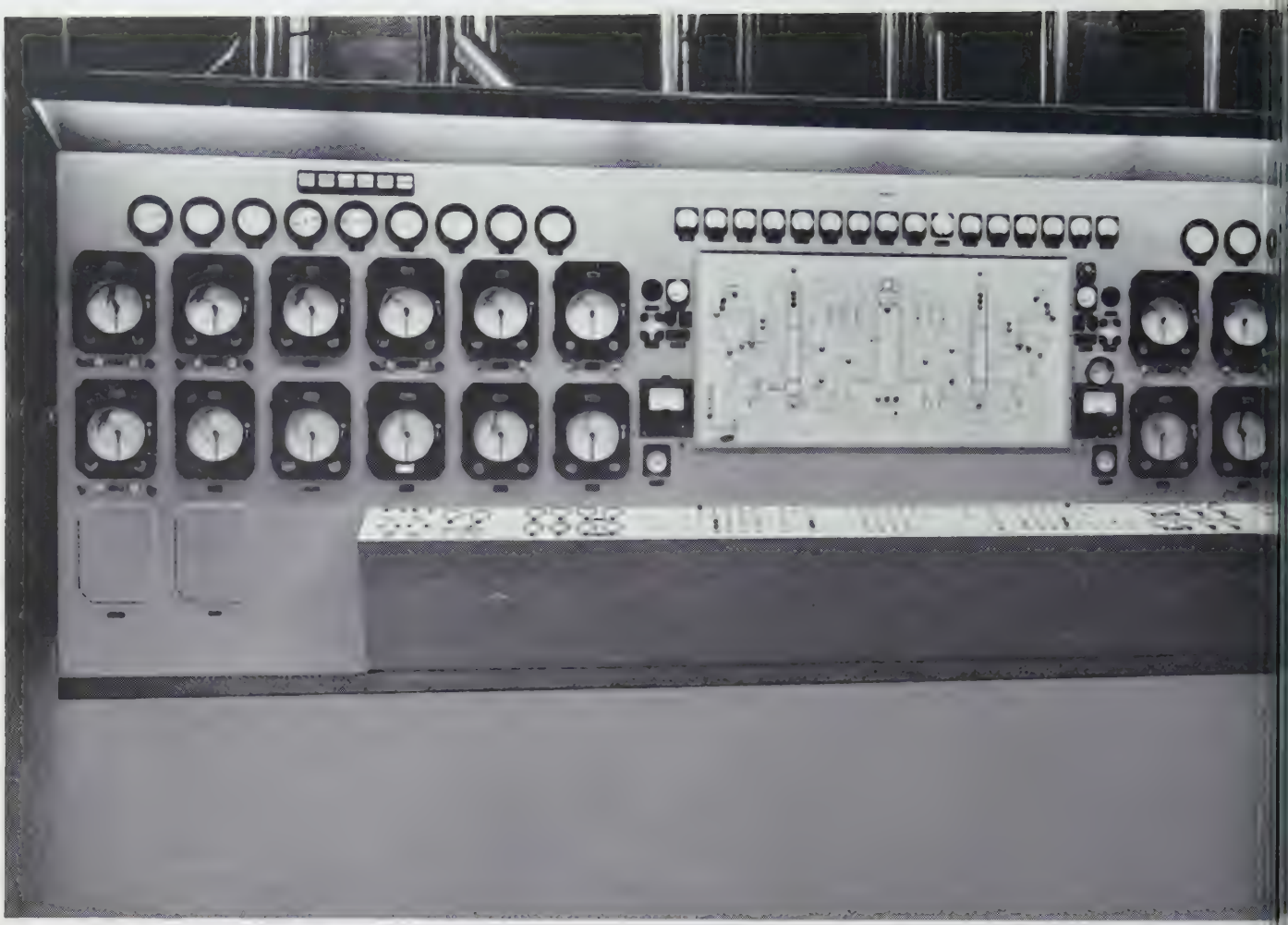
In this test, Number 6 ink was used, and "A" spring tension. The test strips show that average pick velocity of strips with the competitive latex coating was 150 ft. per minute. But strips coated with Dow Latex 630 showed an average pick velocity of 290 ft. per minute . . . also note the reduction in bodystock splitting and the "blacker" black of the ink with the Dow Latex 630 coating.

In addition to greater pick resistance, Dow Latex 630 offers exceptional starch compatibility, excellent mechanical stability, and other outstanding advantages. Together, they spell superior printability . . . paper that permits clear, sharp, true-to-life reproduction with a minimum of problems for the pressman. Type reproduction stands out sharp and clear, too, because coatings made with Dow Latex 630 produce a more uniformly smooth printing surface.

Find out how Dow Latex 630 can help you to produce better paper . . . and boost your sales. For detailed information, write today to THE DOW CHEMICAL COMPANY, Midland, Michigan, Coatings Sales Department 1931FC5.

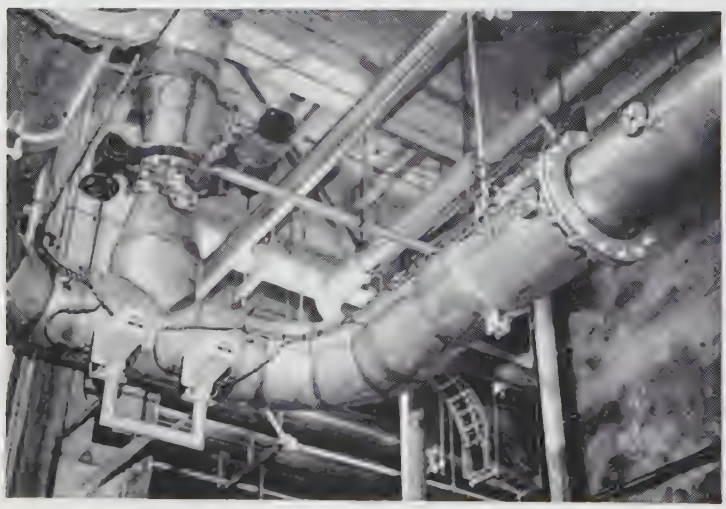
Write for a free copy of this informative booklet on new Dow Latex 630. It contains valuable data and information on how you can improve the performance of your coated papers.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan



Control panel for Kamyr Double Unit Continuous Digester System at Celgar Limited's new mill at Castlegar, B. C.

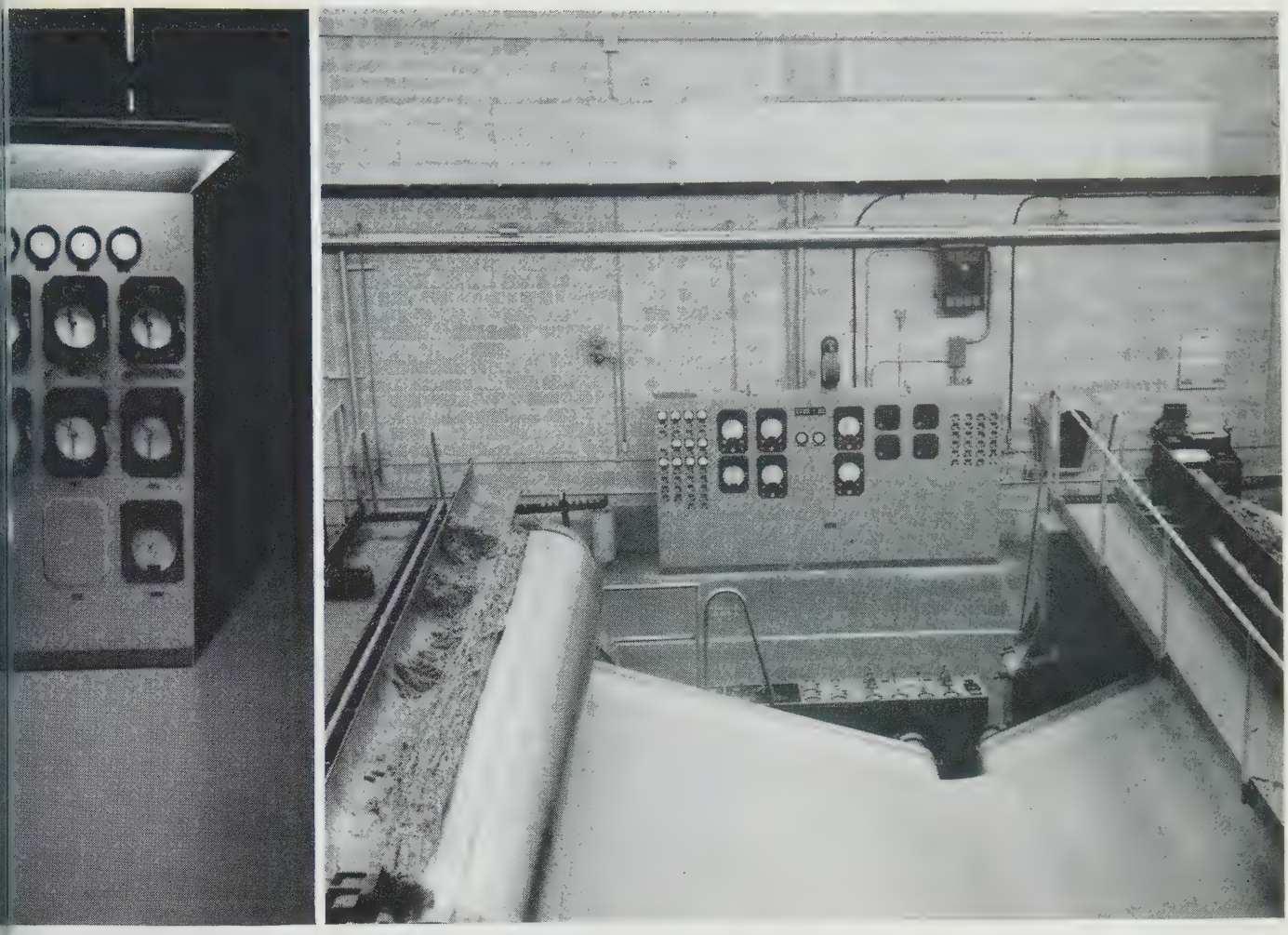
CELGAR FEATURES HIGH



Stock flow and line loss consistency are measured by Taylor Volumetric Flow Transmitters.

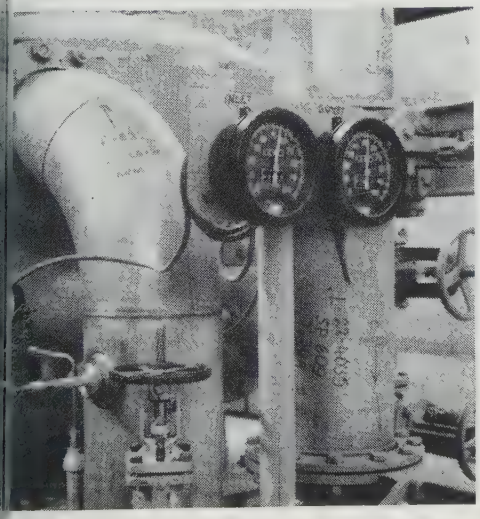
Taylor FULSCOPE* *Recording Controllers automatically regulate Brown Stock Washing.*

Taylor Instruments



Machine-room Wet End control panel.

EFFICIENCY WITH TAYLOR CONTROL



Taylor Volumetric Pressure Indicators on Stock Feed to Screens.

In Arrow Lakes district of the Columbia River Valley, Celgar Limited's new mill at Castlegar, B. C. had to be as fully automated as possible to reduce costs and remain competitive with tide water mills. The 500-ton per day mill is designed to produce very high quality bleached sulphate pulp.

All pulp and chemical processes are under Taylor control. Not shown here are Taylor control systems for Brown Stock Washing, Screening and Cleaning; five-stage Bleach Plant; Stock Preparation Area; Machine Room instrumentation; Black Liquor Evaporators and Chemical Preparation; Recausticizing System.

H. A. Simons Ltd., Consulting Engineer, Vancouver, B. C., under Celgar's direction, was responsible for the engineering design and construction of the mill. Taylor Instrument Companies of Canada Ltd. collaborated with Simons and provided start-up service. According to Mr. D. M. Morrison, in charge of instrumentation at the new mill, "on start-up the instruments behaved well. . . . We were well pleased with new Lin-E-Aire* valves."

Taylor's wide experience in the pulp and paper industry could be invaluable to you. Why not call your local Taylor Field Engineer? Taylor Instrument Companies, Rochester, N. Y., and Toronto, Ontario.

*Reg. U.S. Pat. Off.

MEAN ACCURACY FIRST

KEEVER VICTOR STARCH

a blend of QUALITY STARCHES made to meet your EXACT requirements

How often do your paper-making problems point the finger to starch problems?

Then get acquainted with Keever — and Victor Starch. It's the only blend of wheat and corn now available to the paper industry.

Tests prove that Victor Blended Starch provides a clearer film, greater adhesive strength, more flexibility, a better fiber lay.

Victor Starch makes it possible to produce a formula best suited to nearly every starch operation in paper making.

Keever starch technicians will help you work out the ideal formula variations that make Victor Starch "custom-made" for individual requirements.

For additional information, write for Keever Data Sheet 170.

THE KEEVER STARCH COMPANY

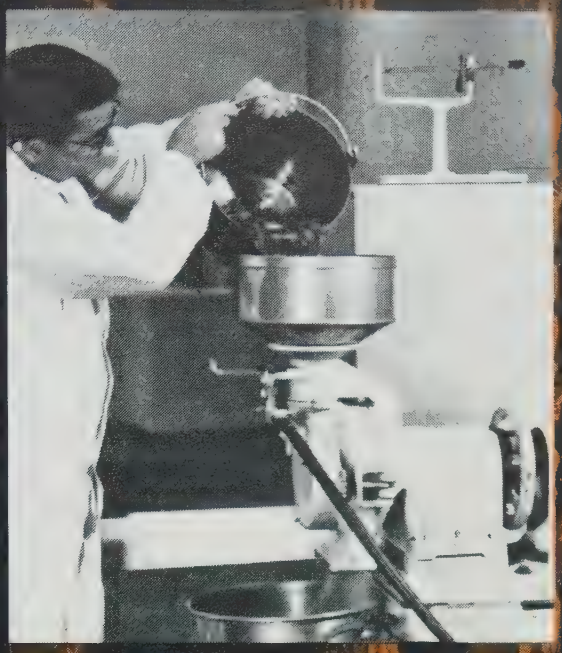
538 East Town Street, Columbus 15, Ohio

Processors of grain products for industry since 1898

WHEN THE CHIPS ARE DOWN . .

fmc's®

paper research team goes to work on your problem !



Soda ash, caustic and chlorine users now get unparalleled technical assistance from FMC in solving tough paper problems.

The new wing recently added to our Princeton Research Center brings together paper experts from three divisions of FMC Inorganic Chemicals Department to form a customer service team with unusual depth of experience in this specialized field.

Working in one of the best equipped paper laboratories outside the paper industry, these technicians are able to duplicate fundamental paper manufacturing steps and to carefully test and evaluate the results. Their work is aided immeasurably by our modern analytical research laboratories at the same location.

Next time you have a problem, call on your nearest FMC district office.

CHLORINE

SODA ASH
Light and Dense Grades

CAUSTIC SODA
50% and 73% Liquid,
Regular and Rayon Grades;
Flake, Solid and Ground

fmc
FOOD MACHINERY AND CHEMICAL CORPORATION ®

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Chlor-Alkali Division

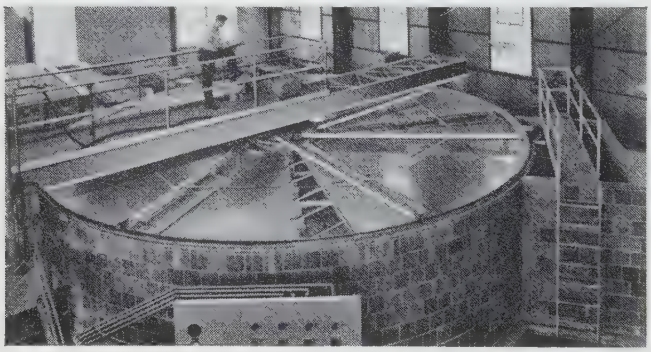
General Sales Offices:
161 E. 42nd STREET, NEW YORK 17

Here are answers to your water and waste treatment problems-

...Process and Boiler Feed Water

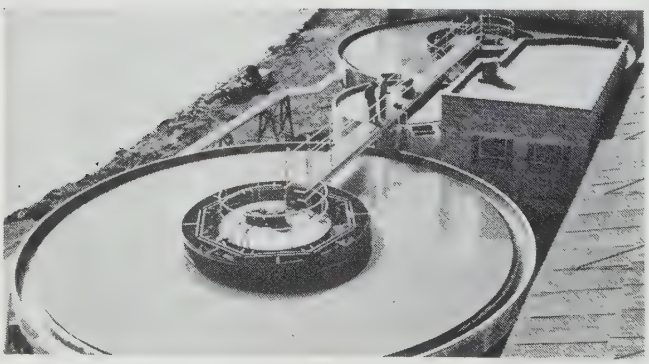
The **ACCELATOR®** high rate treatment plant saves up to 80% in space. It clarifies or softens and stabilizes water in a single basin, and produces more stable effluent — a slurry contact — not a sludge blanket unit. Hot process softeners, Zeolite softeners and demineralization equipment are offered for boiler feedwater treatment. A full line of feeders, pressure filters and equipment for gravity filters including meters, rate controllers, control panels, and operating tables supplements the high rate line. **Bulletin 1825**

...White Water and Waste Treatment...



CLARIFICATION *by flotation*

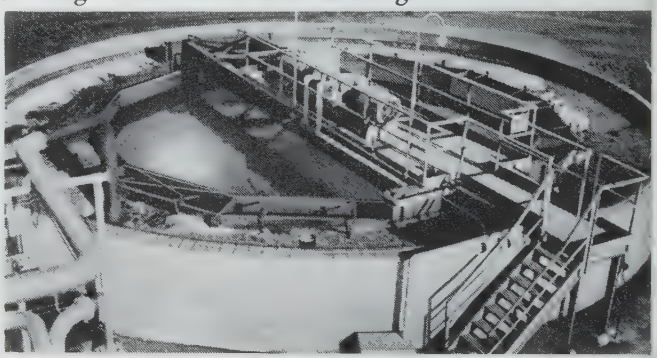
The **SEDIFLOTOR®** clarifier is offered where space is limited and high-rate clarification is essential. This air flotation unit is ideal for removing floatable suspended solids and gives most effective fibre and heat recovery. **Bulletin 6051**



CLARIFICATION *by chemical treatment and settling*

The **CYCLATOR®** clarifier treats wastes containing suspended solids of very fine or colloidal nature which require chemical coagulation for adequate clarification. This unit can provide solids recovery and heat recovery by reuse of the clarified effluent. Sedimentation clarifiers with skimmers and scrapers, are part of the INFILCO line. **Bulletins W-800 and 850**

...High Rate Activated Sludge



The **AERO-ACCELATOR®** high rate activated sludge plant provides a multi-purpose unit for BOD reduction. Rapid mixing, biological oxidation and clarification under high loadings are effected within a single basin. **Bulletin 6510-D**

...Stabilization Ponds

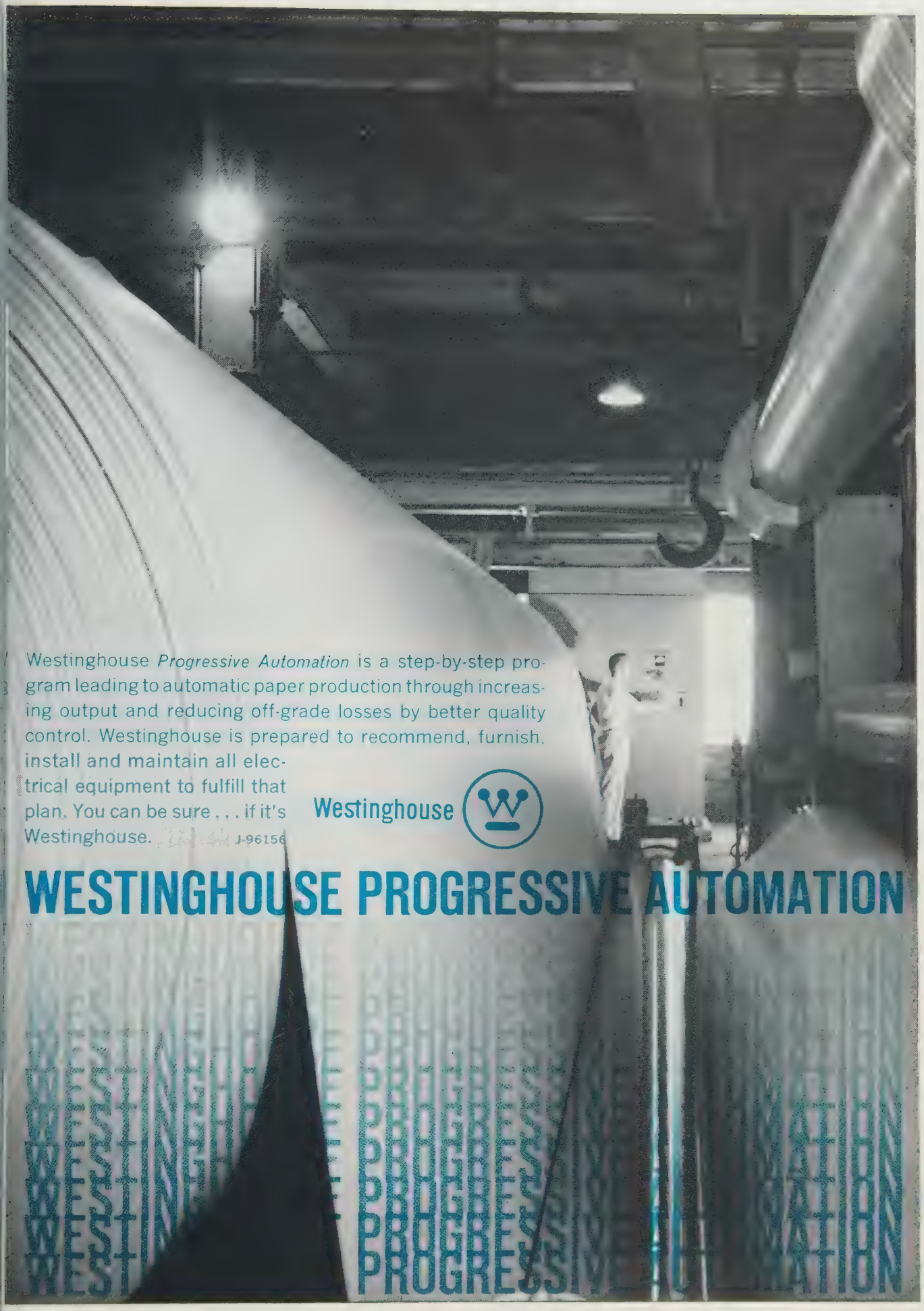
The **VORTAIR®** aerator is a mechanical turbine unit originally designed for oxygenating stabilization ponds and lagoons at paper mills. It provides effective aeration for activated sludge. Since this unit transfers oxygen directly from the atmosphere, it requires no compressors, yet oxygen transfer efficiency is high. It may be mounted on piers or pontoons. **Bulletin 6620**

These are a few of the products for water and waste treatment in the complete INFILCO line.

Write for our condensed catalog and other bulletins.

INFILCO Inc.
General offices • Tucson, Arizona
Field offices throughout the United States and in other countries

Subsidiary of General American Transportation Corporation


Westinghouse *Progressive Automation* is a step-by-step program leading to automatic paper production through increasing output and reducing off-grade losses by better quality control. Westinghouse is prepared to recommend, furnish, install and maintain all electrical equipment to fulfill that plan. You can be sure . . . if it's Westinghouse.
J-96156
Westinghouse
WESTINGHOUSE PROGRESSIVE AUTOMATION

RAY-MAN CONVEYOR BELT

RAY-MAN Troughs Deeper, Trains Easily ...For Highest Pulp and Chip Capacity

Ray-Man conveyor belt and 45° idlers provide pulp load capacity at this Crown-Zellerbach Pacific coast paper mill. Consider these advantages of Ray-Man for your conveyors:

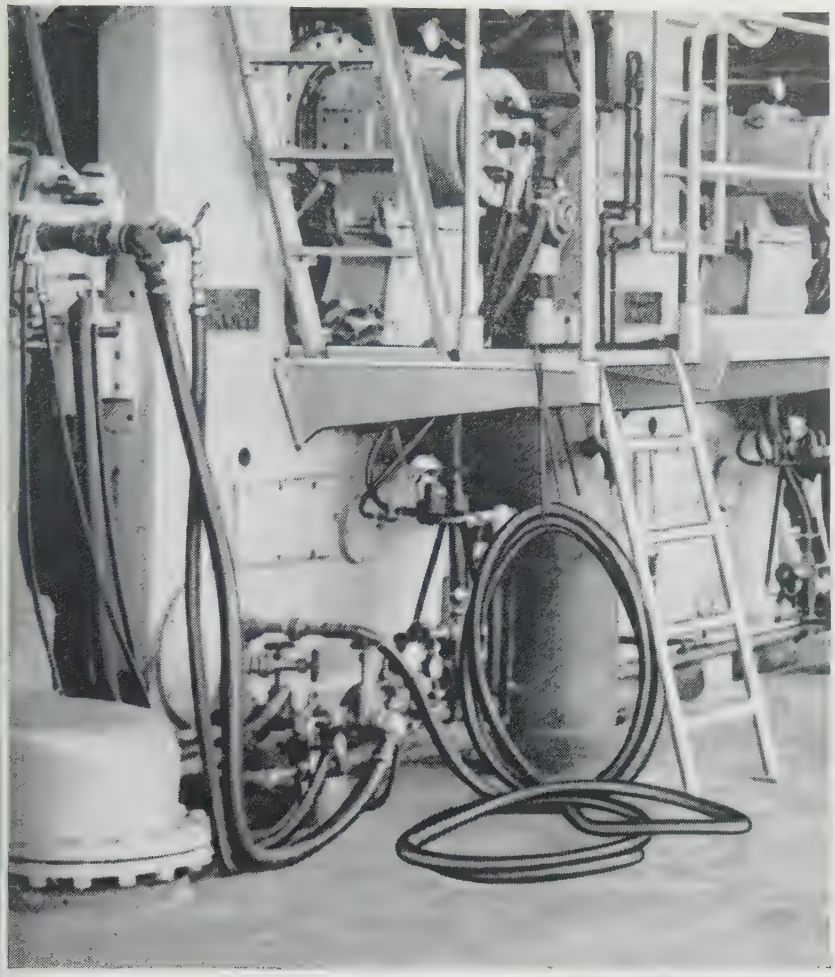
- **High Cover-adhesion All Around**—top, bottom, and edges
- **Full Cover Thickness Used**—no breaker needed, longer cover life
- **Splices Last Longer**—holds fasteners better
- **More Troughable and Trainable**—highly flexible, double Compensated
- **Designed for 45° Idlers**—guaranteed against separation at idler hinge line
- **Operates on Smaller Pulleys**
- **Impact Cushioned**—resists ripping

Ray-Man is mildew-proof and moisture resistant . . . can be made oilproof for use with chippers. Ask your R/M distributor about Ray-Man or about log conveyors. Write for Bulletin M303.

R/M'S PATENTED WEDLOK SPLICE Provides Dependable, High-Tension Mechanical Splice with a Vulcanized Splice-Rating on Ray-Man Conveyor Belts at Crown-Zellerbach. Get "More Use per Dollar" . . . Save Time and Money with Wedlok Splice. Write for Bulletin M380.

RM-108

RAYBESTOS-MANHATTAN, INC.
MANHATTAN RUBBER DIVISION • PASSAIC, N. J.
ENGINEERED RUBBER PRODUCTS



HOMOFLEX Paper Mill Hose Is Light . . . and Flexible as a Rope

Homoflex is the easiest handling wash-down hose made and weighs less than any other hose for equal working pressure.

- **Super-Strong** — assures longer, trouble-free service life
- **Precision Built**—Homogeneous construction provides inseparable tube-to-cover bond
- **Kinkless**—coils and uncoils freely in any direction
- **Mandrel-Made**—no pre-set twist
- **Safer, Easier Coupling** — inside and outside diameters are uniform
- **Available With Built-In Tapered Rubber Nozzle**—prevents machine damage

Write for Catalog M5.

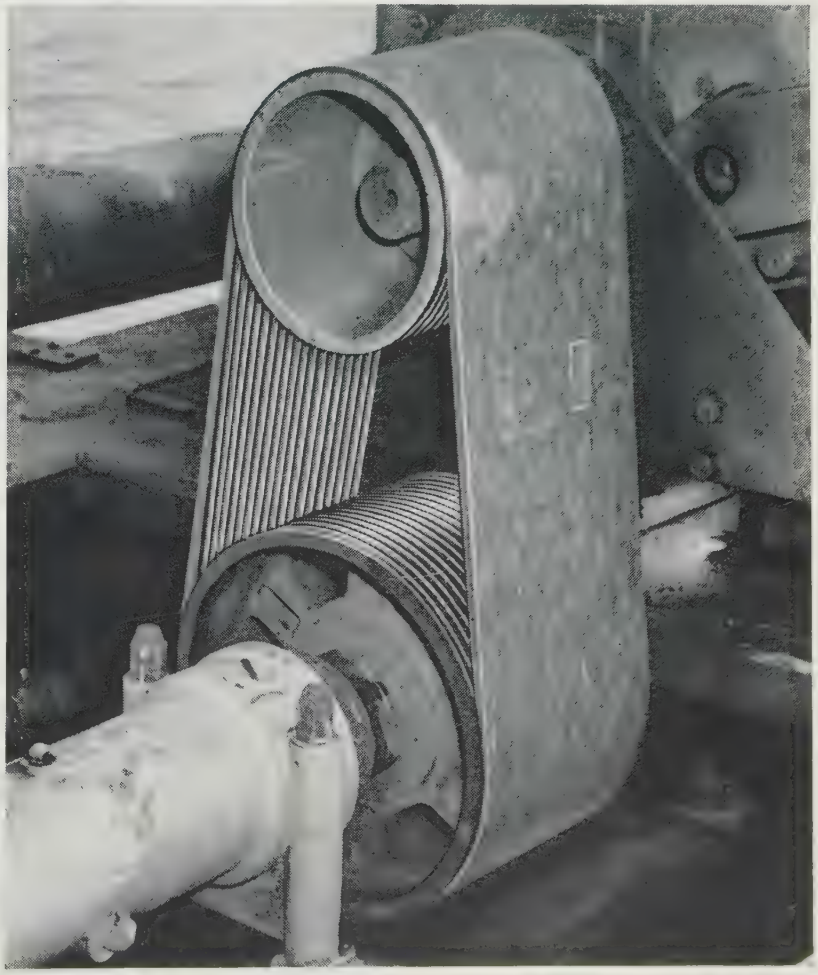
R/M POLY-V® Drive Delivers More Power in Less Space . . . with More Reliability

A single, endless V-ribbed belt across full width of sheaves with mating grooves. Gives more power per inch of width and advantages never possible with conventional multiple belt drives.

- **Simplicity**—*two* belt cross sections meet *every* heavy duty requirement
- **Reliability**—less maintenance, less take-ups . . . longer belt and sheave life
- **No Matching**—single unit belt eliminates "length matching"
- **Better Performance** — maintains groove shape, constant pitch and speed ratios . . . runs smoother, cooler

WHEN YOU CHANGE DRIVES CONVERT TO POLY-V* . . . AND BE SURE.
Write for Bulletin M141.

*patented



MADE ESPECIALLY FOR THE PAPER INDUSTRY

GLIDDEN
ZOPAQUE®
LD-C

Anatase grade TiO_2 combining the best features of both anatase and rutile grades for paper coating

NOW, the better brightness of anatase TiO_2 is combined with the ease of dispersion and low viscosity features of rutile grades . . . in Glidden ZOPAQUE *LD-C*.

LD-C has properties comparable to rutile. It is equally well suited for on and off machine, size press and calender coating. Compatible with all other common paper coating pigments and adhesives.

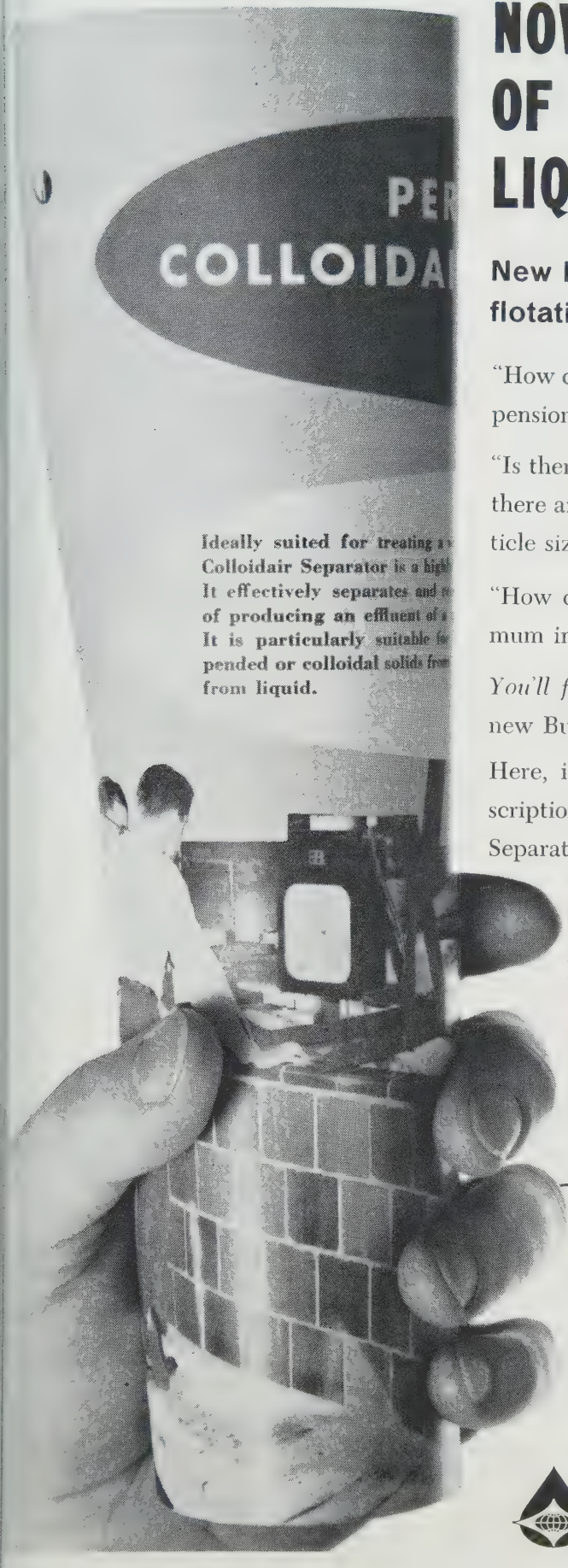
Being an anatase grade, new *LD-C* is for coating all nonwaxing plain and printed paper and board. And *LD-C* is priced as an anatase. Some users are obtaining savings of up to 2¢ per pound.

Higher machine speeds, heavier coating weights and other advantages are inherent in new *LD-C*. To get the full story, or samples, call your Glidden representative or our Baltimore headquarters.

QUALITY Glidden PRODUCTS

THE GLIDDEN COMPANY
FINEST PIGMENTS FOR INDUSTRY
Chemicals Division • Pigments and Color Department
Baltimore 26, Maryland

MANY GLIDDEN TECHNICAL FACILITIES ARE AT YOUR SERVICE for development or testing work in paper. Write for this new brochure — just off the press — *Paper Research and Development Laboratories.*
AT YOUR SERVICE TO HELP YOU SOLVE TECHNICAL PROBLEMS IN THE MANUFACTURE OR COATING OF PAPER AND PAPERBOARD
PAPER RESEARCH AND DEVELOPMENT LABORATORIES OF THE GLIDDEN COMPANY



NOW... ANSWERS TO SOME OF YOUR QUESTIONS ABOUT LIQUID-SOLIDS SEPARATION

New bulletin gives useful facts on dissolved-air flotation unit

"How can I get a high concentration of solids from a liquid suspension, for re-use or easy waste disposal?"

* * *

"Is there a way to get economical liquid-solid separation, when there are frequent variations in temperature, viscosity, pH, particle size, particle density, and entrainment concentration?"

* * *

"How does the Colloidair Separator keep heat loss to a minimum in the clarified liquid?"

* * *

You'll find answers to these and many other questions in our new Bulletin 4772.

Here, in six pages of facts and illustrations, you have a description of the design and operation of the Permutit Colloidair Separator—the dissolved-air flotation unit that eliminates almost all labor and supervision, and operates automatically and continuously.

If you are interested in this type of liquid-solids separation, we recommend that you study a copy of this bulletin. No obligation. Simply send the coupon below or drop us a note.

THE PERMUTIT CO. a division of Pfaudler Permutit Inc.
50 West 44th St., New York 36, N. Y.

Gentlemen:

I would like information on reducing operating costs and improving liquid-solids separation. Please send me your Bulletin 4772, "Permutit Colloidair Separator."

Name_____
Company or Municipality_____
Title_____
Street_____
City_____ Zone_____ State_____

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

DICALITE®
TECHNICAL REPORT
DICALITE DEPARTMENT • GREAT LAKES CARBON CORPORATION • 612 SO. FLOWER ST., LOS ANGELES 17, CALIFORNIA

New Dicalite BULK-AID for Paper Products

TRADEMARK

Dicalite BULK-AID is a new development in inorganic fillers, with particle size range and distribution carefully controlled to give maximum bulking characteristics in paperboard and paper products. BULK-AID has the lowest apparent or bulk density of any known mineral filler for papermaking use, thus providing required caliper at lower weights. One example is that of a 40-point groundwood sheet whose weight was reduced from 29.2 lbs/ft^3 to 27.3 lbs/ft^3 by the addition of 10% BULK-AID.

The light weight and bulking characteristics of BULK-AID make it especially suitable for use in paperboard; its high brightness and excellent retention are also of considerable value. BULK-AID lowers the furnish cost and increases pulp mileage in top liners for patent white paperboards. Its brightness and opacity raise the quality of underliners at the same time it extends the furnish.

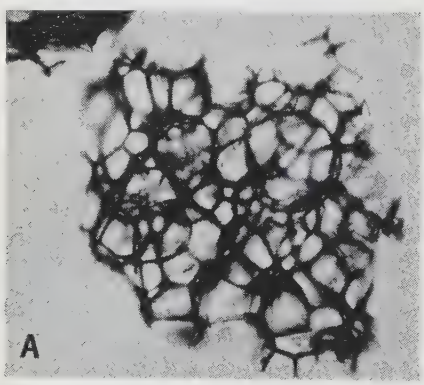
Dicalite BULK-AID is an amorphous mineral, technically an aluminum silicate, produced from a volcanic mineral known as perlite by a special process developed by Great Lakes Carbon Corporation. BULK-AID is inert, insoluble in water, acid or mild alkalies. It is grit-free, and exhibits no reaction with alum in sizing or with other papermaking chemicals. It is readily dispersed in any furnish, does not cause foam, and will not fill felts.

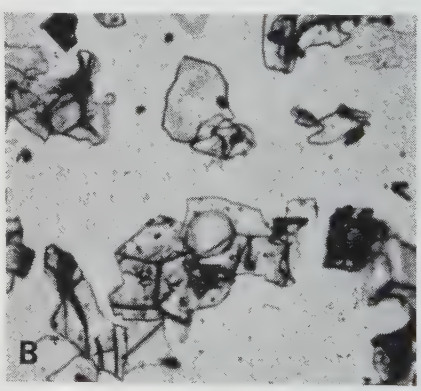
Among BULK-AID's physical characteristics are these:

Color: White
Average G.E. Brightness: 83
Loose weight: 4½ lbs/ft^3 average
Bulk densities in paperboard: 15 lbs/ft^3 average.
Particle size: 80% less than 10 microns

Extensive testing has shown BULK-AID to be successful in actual paper mill production. Most of these tests were on cylinder machines for paperboard production, but limited tests indicate its value in many slow speed fourdrinier applications.

Your Dicalite engineer will be glad to discuss BULK-AID with you and to advise on possible product applications in your own plant.





When perlite is crushed and then suddenly heated to the proper point in its softening range, it pops like corn into particles like that shown in photomicrograph A, containing a myriad of microscopic sealed cells. The size of the original particle and the application of heat are both important, and are critically controlled. This is the expanded material from which BULK-AID is produced. Controlled milling and air classification by an exclusive Great Lakes Carbon Process are the major steps in making BULK-AID, typical particles of which are shown in photomicrograph B.

© 1961 GREAT LAKES CARBON CORPORATION • LOS ANGELES, CALIF.

Gordon G. Halvorsen

DICALITE'S "MAN ON THE SPOT"

The development of Bulk-Aid, to meet the industry's need for an extremely low density bulking agent, was initiated by Gordon Halvorsen, Product Sales Manager for Dicalite, and he has been closely identified with its tests and product application work from the beginning.

Halvorsen has an extensive background in research and development work, beginning with his graduation from the University of Minnesota with a degree in Chemical Engineering. Prior to joining Great Lakes Carbon in 1940, Gordon had been engaged in technical and laboratory work in the pharmaceutical, corn processing and water treatment fields, and continued his research work in the Dicalite product laboratories for the first 5 years of his association.

Halvorsen is the author of several technical papers, and has contributed to both paper industry and brewing publications. Among his technical society memberships he lists TAPPI, American Society of Sugar Beet Technologists, Master Brewers Association of America, and others in the brewing and drycleaning fields.

NEW DATA SHEET

on Dicalite *BULK-AID* gives more complete information on physical and chemical properties, and on its advantages in papermaking. Write for your copy to Dicalite Dept., 612 So. Flower St., Los Angeles 17, Calif.

PAPER NEWS

from Allied Chemical

- *dyes for tinted book papers*
- *chlorine safety program*
- *super-high-gloss coatings*

• *eye strain eased by new tinted book papers colored with Allied Chemical paper dyes*

White paper reflects as much as 93-95% of the light—black ink 3%. New color-coordinated papers and inks, like those used in this insert, reflect only about 75% and 10% respectively—sufficient contrast for easy reading *without* fatigue, according to leading color experts.

Cost-conscious manufacturers of tinted papers are using National® "tailor-made" paper dyes. National Paper Dyes give you modern dyestuffs designed for continuous dyeing, dry application and other money-saving techniques. Why not let a National representative show how these dyes can save money for you?

NATIONAL ANILINE DIVISION

This entire insert is printed on 80 lb. Appleton Coated Impact Suntex; ink is blue. Yet, note how your eyes see "highlights" in this picture.

• *how Solvay helps customers with complete ch*

Safety posters list precautions to be taken in handling chlorine and procedure in case of accidents. Safety manuals, films and educational literature are also provided.

Solvay provides consultation on chlorine safety facilities and procedures. Here, technical service representative explains use and care of protective clothing.

program

Employees clear "danger" area in emergency drill. Safety training of personnel is another important facet of Solvay's integrated safety program for customers.

Equipment from a Solvay Chlorine Emergency Kit being used to stop leakage in tank car dome. Similar kits are available for 150-lb. cylinders and one-ton containers.

Photos on this page show several phases of a typical program in operation at a customer's plant. If you are a user of chlorine, the same service is available to you. Ask for information. ■ **SOLVAY PROCESS DIVISION**

• *new super-high*

ard coatings now make overwrappings unnecessary

A new heat treatment using A-C Polyethylene marketed by Plastics Division imparts *super* high gloss to waxed paperboard...lets you dispense with overwrapping in many cases. It's ideal for frozen food and ice cream packages...butter and oleo...bread wrappers.

You can use this new technique while realizing all the advantages of A-C Polyethylene wax coatings: greater resistance to grease, moisture, scuffing and abrasion...smooth plastic-like feel...positive lock at freezing temperatures... brighter printing effects.

For details on super high gloss with A-C Polyethylene, write us.

PLASTICS DIVISION

• *basic to America's progress*

Allied Chemical

For more information, write
Allied Chemical Corporation,
61 Broadway, New York 6, New York.

In Canada:
Allied Chemical Canada, Ltd.,
1450 City Councillors Street, Montreal

• *principal products for the paper industry*

BARRETT DIVISION—BARRETT building materials.

GENERAL CHEMICAL DIVISION—Aluminum sulfate; Glauber's salt; Salt cake; Sodium silicate; Sulfuric acid.

NATIONAL ANILINE DIVISION—Adipic acid; CAPROLAN nylon fiber; Fumaric acid; HARMON pigments for printing inks; Maleic anhydride; NACCONATE diisocyanates (in coatings); NACCONOL detergents and emulsifiers; NACCOTAN dispersing agent and mordant; NADONE cyclohexanone; NATIONAL paper dyes; Phthalic anhydride.

NITROGEN DIVISION—Ammonia liquor; Anhydrous ammonia; Formaldehyde; Methanol; Polyethylene glycol; Triethanolamine; U. F. Concentrate-85; Urea.

PLASTICS DIVISION—A-C polyethylenes—Emulsifiable for paper size or coating; hot melt low molecular weight for coatings; CUMAR resins; ELASTEX plasticizers; Fiber pitch; PLASKON urea resins, Solvents, Tar acids.

SEMET-SOLVAY DIVISION — Coke and by-products; WILPUTTE by-product coke ovens and coal chemicals plants and engineering services.

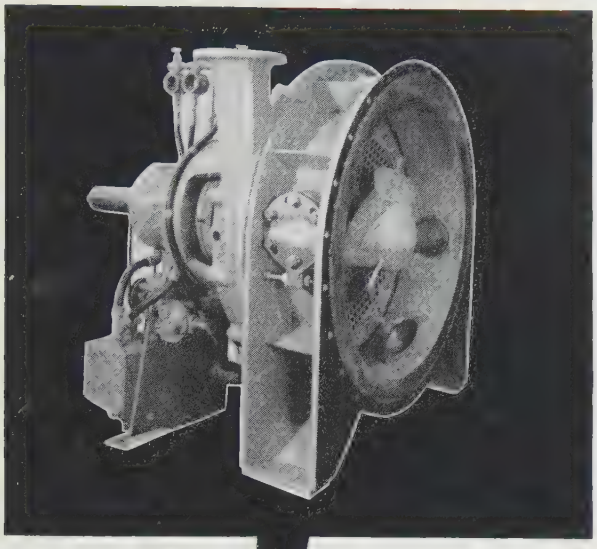
SOLVAY PROCESS DIVISION — Ammonium bicarbonate; Calcium chloride; Caustic soda; Chlorine; Hydrogen peroxide; MUTUAL salt cake; Soda ash.

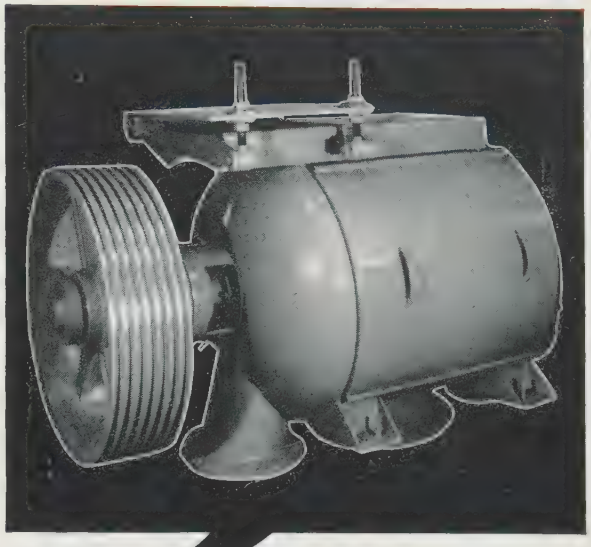
INTERNATIONAL DIVISION—Marketing Allied Chemical products abroad.

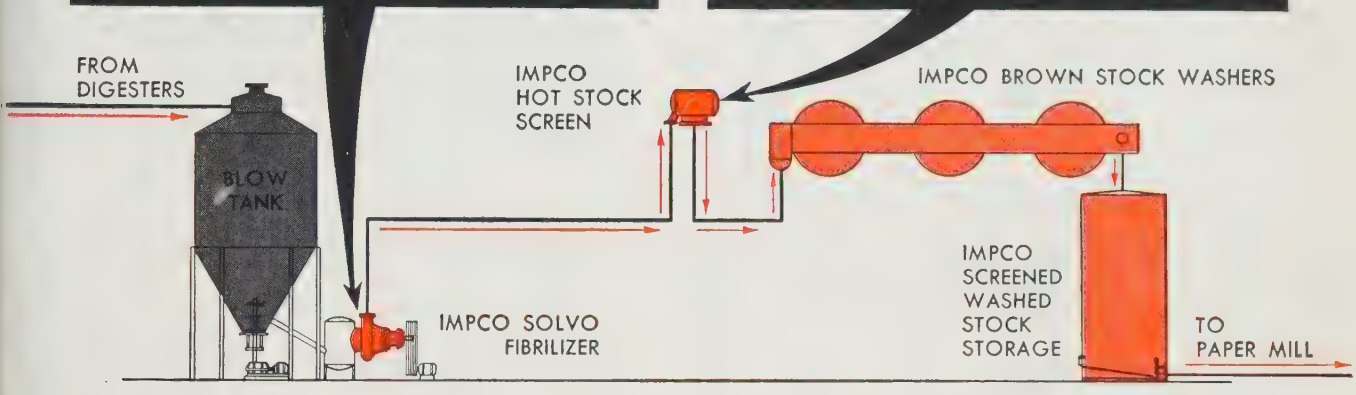
Items above appearing in light face capital letters are Allied Chemical trademarks.

Printed i

Impco *Again* Simplifies the Pulping Process with the Fibrilizer and Hot Stock Screen







The new Impco Fibrilizer and Hot Stock Screen combination has opened the door to vast savings for the industry.

The Solvo Fibrilizer produces a combined action of pulp classification, complete soft knot defibering (not refining), hard knot shredding, higher initial yield and eliminates knot handling. Its built-in pumping action eliminates the need for a stock pump. All these operations are being accomplished for about one-half horsepower days per ton.

The new Impco Hot Stock Screen, installed directly ahead of the primary stage brown stock washer, is now producing quality pulps in several mills. This development virtually obsoletes the need for separate washed-stock screening of most paper and all board grade pulps.

The arrangement shown can be installed for high yield Kraft and Sulphite pulps with only the screen rejects requiring refining.

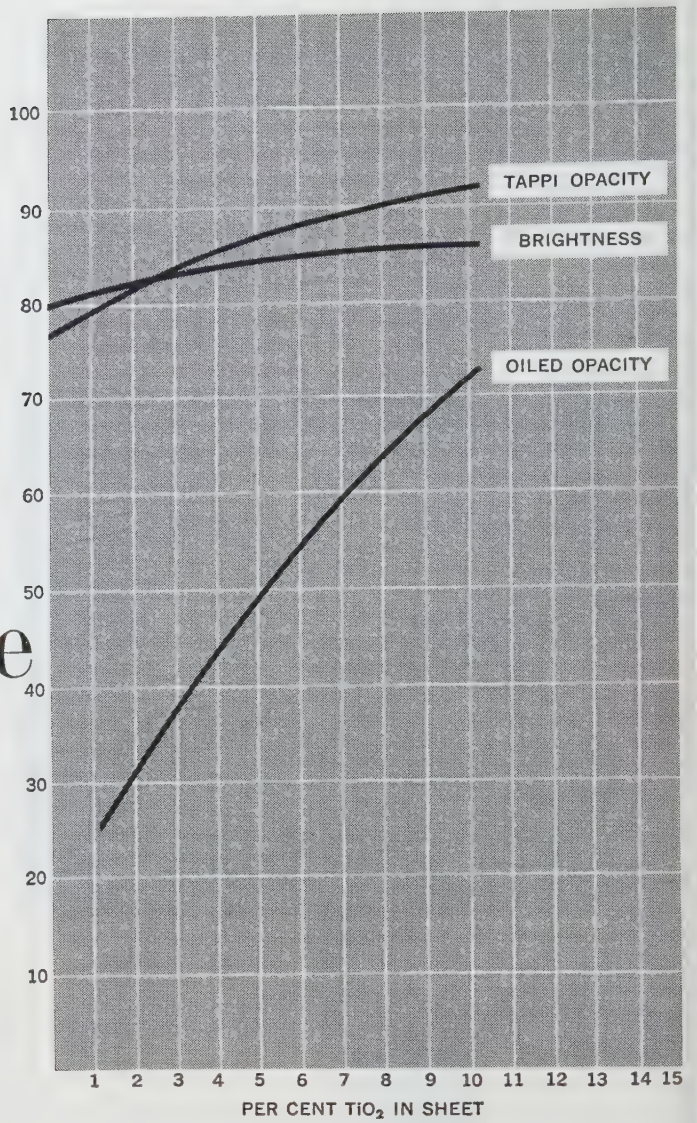
IMPCO®

IMPROVED MACHINERY INC.

NASHUA, NEW HAMPSHIRE

IN CANADA: SHERBROOKE MACHINERIES LIMITED, SHERBROOKE, QUEBEC

an outstanding titanium dioxide pigment made specifically for YOU



UNITANE® 0-120 This new pigment has been developed especially for the paper industry to give maximum retention. Designed specifically for wet-end additions, it has the same high brightness and opacity as the other well-known grades of UNITANE, and in tests with chlorinated starch has repeatedly given higher retention than any other titanium dioxide tested. These excellent properties are easily translated into savings for you—maximum opacity with minimum white water losses, high brightness with minimum show-through at lower basis weight, and good printed opacity. The curves illustrate the brightness, TAPPI opacity and oiled opacity obtained with UNITANE 0-120 at various concentrations of TiO_2 in the sheet.

A comprehensive report on the application of UNITANE 0-120 is available through your Cyanamid Pigments representative. Contact him today or write

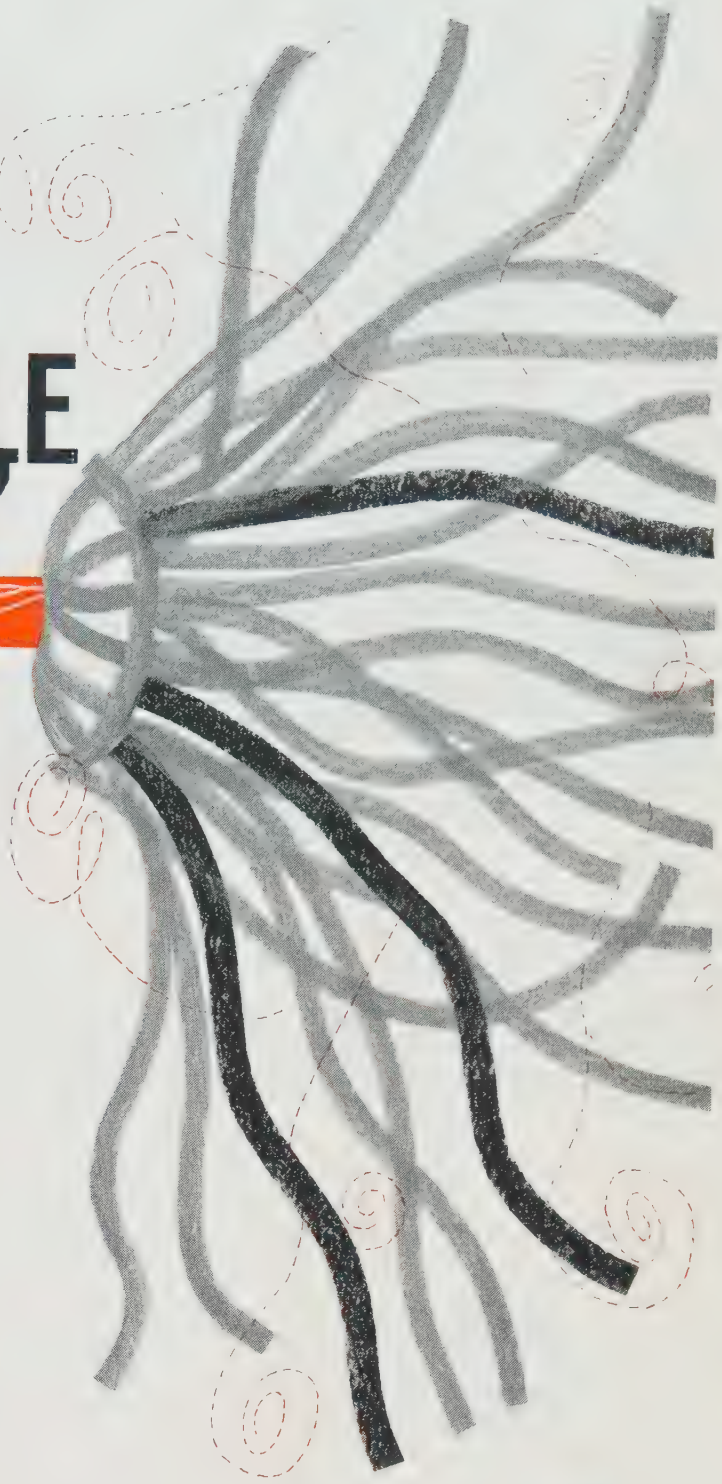
CYANAMID

AMERICAN CYANAMID COMPANY • PIGMENTS DIVISION • 30 Rockefeller Plaza, New York 20, N. Y.
Branch Offices and Warehouses in Principal Cities

Lighter WHITER AND BRIGHTER WITH UNITANE

DON'T TACKLE "DUSTING" WITH A MOP use

Penford Gum



Dusting can happen at the paper mill or at the printer's. Whatever the cause, prevention is the only "cure."

The Penford Gums (hydroxy ethyl ether starch derivatives) combat dusting effectively when used as adhesives in coatings . . . as pure surface sizes applied at the press or on the calenders . . . and to hold down wiry fibers on uncoated sheets. They offer:

1. *Exceptional adhesive pigment-binding properties*
2. *Tough, flexible filming characteristics*
3. *Improved water-holding ability*

One of our technical service representatives will be glad to come to your plant to show you how Penford Gum can help you improve your paper on *all* counts without increasing costs. Call or write Penick & Ford today.

Penick & Ford

PENICK & FORD, LTD.

INCORPORATED

750 THIRD AVENUE, NEW YORK 17, N. Y.
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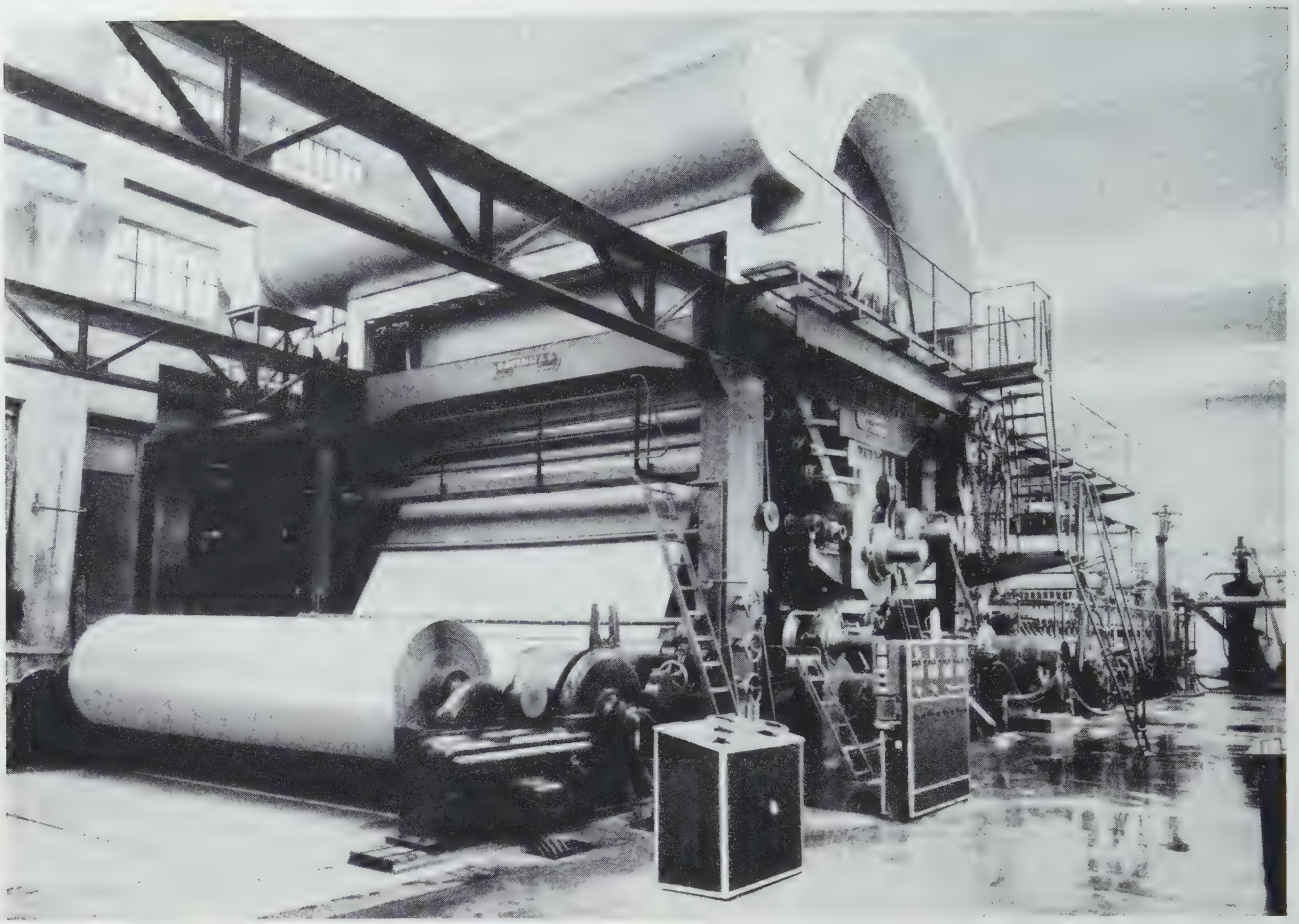


The widest Yankee machine for the manufacture of M.G. Kraft papers

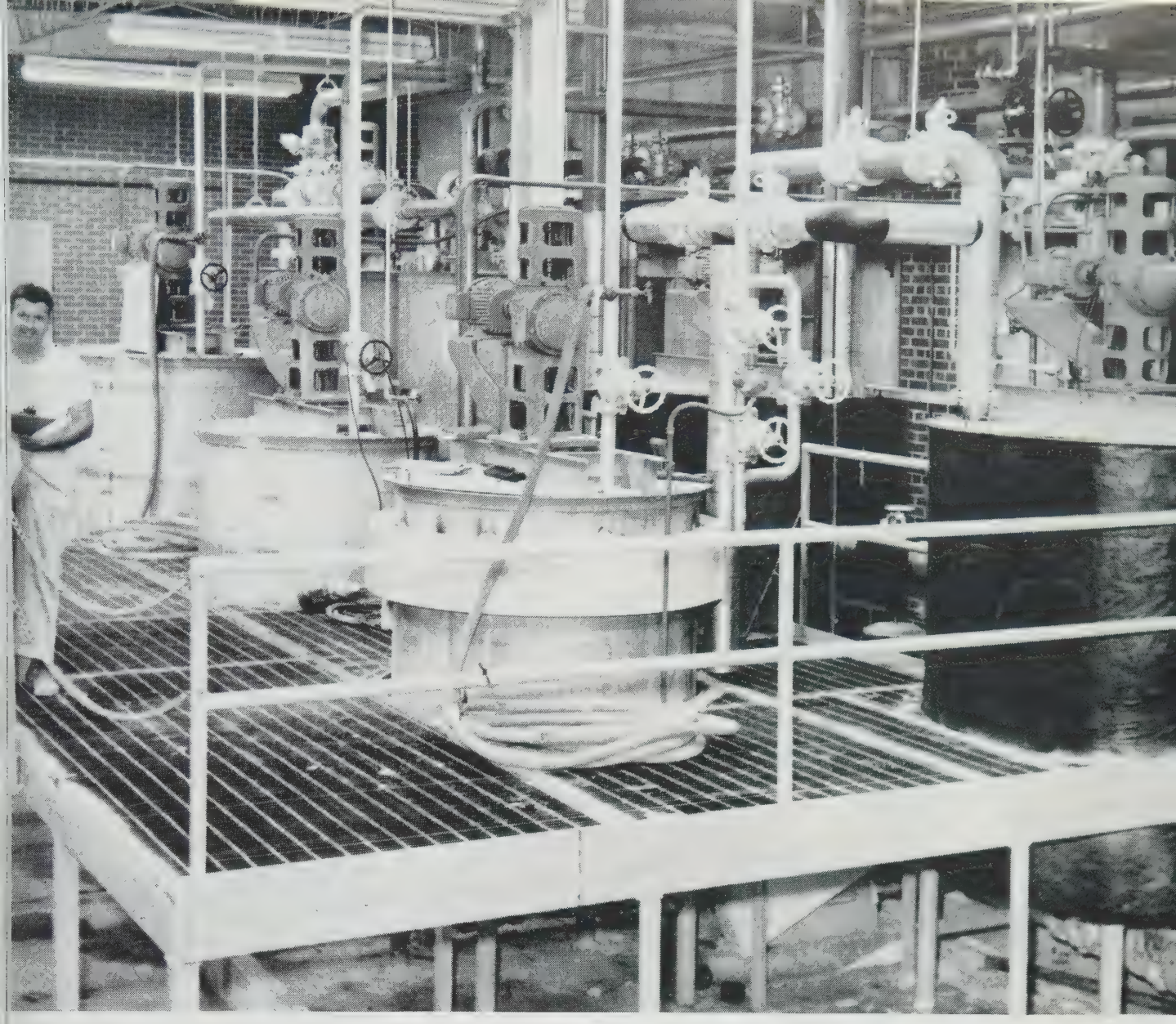
- 210 inch wire width.
- 16 foot diameter Yankee Cylinder, 218 inches wide, weighing 99 tons for a steam pressure of 66 psi.
- Vacuum flow box (patented in Germany and abroad).
- 47 inch diameter Suction Couch Roll arranged for adjustable width of the suction zone (patented in Germany and abroad).
- Suction Press.
- Hydraulic Pope Reel (patented in Germany and abroad).

O. DÖRRIES A.G. DÜREN

Eisengießerei und Maschinenfabriken · Western Germany

Agents: Bulkley, Dunton Pulp Company, Inc. 295, Madison Avenue, New York 17 N.Y./USA

Telephone: Murray Hill 9-6400 Telex: TWY - NY 1 - 2092



Compact station employing seven LIGHTNIN Mixers feeds adhesive and coatings at St. Joe Paper Company, Port St. Joe, Florida.

How to mix coatings and keep them mixed

If coatings and adhesives pose production problems in your mill, here's proof that they needn't.

In this kraft board mill, the coating and adhesive plant is a smooth-running operation that feeds uniformly consistent materials to the laminator 24 hours a day. A large part of the secret of its success is good mixing with LIGHTNIN Mixers.

How coating process works

1. In the slurry make-up tank at the rear, a turbine-type LIGHTNIN Mixer swiftly incorporates dry clay into the liquid, breaking down all lumps and agglomerates.
2. Slurry then goes to the holding tank. Here another LIGHTNIN Mixer keeps it in uniform suspension without settling and without excess surface action.
3. Adhesive make-up and cooking take place in the next two tanks. LIGHTNIN Mixers disperse the solids evenly in these 500-gallon tanks, keep starch moving all through the cook, and prevent hot spots from developing.
4. Finished adhesives go to the two side tanks where LIGHTNIN Mixers hold them uniform and prevent skinning over while cooling.

Secret: controlled mixing

Four *different* mixing jobs. LIGHTNIN Mixers do them all—with never a worry about consistency or uniformity.

Wherever you need controlled mixing or agitation to help your mill system work better, you can get it with LIGHTNIN Mixers. You get the precise power level you need to accomplish the job you want done within a given time. Results are guaranteed.

Your LIGHTNIN Mixer representative can give you the details. He's listed in Thomas' Register. Or write directly to us.

"Lightnin® Mixers"

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 142-e Mt. Read Blvd., Rochester 3, N.Y.

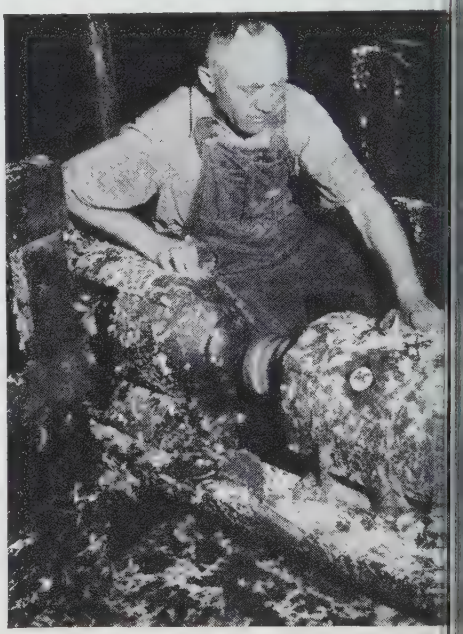
In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.
In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England

ideas and news

One-man maintenance for new vertical pump: This redesigned A-C pump gives quick access to internal parts. One mechanic can remove entire rotating element without need of an electrician to disconnect the motors or a pipe fitter to break piping. In addition, vertical design takes 25% less floor space than horizontal units.

No bake-out for wet motor: This Super-Se motor, installed in a low-lying work roo of a Connecticut paper mill, has repeatec been under 5 to 6 feet of water. When t flood water recedes, the motor goes ba into service without costly, time-consumi "bake-out." Poxeal and Silco-Flex insu tions, used in Super-Seal motors, are i pervious to moisture, dust, dirt, oils a most acids and alkalies.

So low, two fit where one used to go: SpaceMaker control center is the first completely new 2- to 5-kv motor controller in more than a decade. Its compact, two-high design cuts floor space in half. New flame-retardent, track-resistant Super Pyro-Shield insulation reduces controller size and weight, adds to reliability. Full drawout construction makes this the safest, most accessible controller available. The door cannot be opened unless the contactor is disconnected with all "live" connections isolated. One man can roll the contactor carriage out of the enclosure for obstruction-free inspection and maintenance. Contacts are completely accessible.



Which one of these productive ideas coul be working for you?

A motor that shrugs off floods . . . a high-voltage motor control center a vertical pump with simplified maintenance. These examples demonstr the extra value that is standard with A-C . . . the greater efficiency a added productivity which are yours when you buy A-C products, syste and services. Call your Allis-Chalmers representative for details on "worth-more" features. Or write Allis-Chalmers, Industrial Equipm Division, 903 S. 70th Street, Milwaukee 1, Wisconsin.

A-C INDUSTRIAL EQUIPMENT DIVISION: motors, generators, controls, rectifi pumps, compressors, crushers, mills, screens, kilns, coolers, industrial syste

VALLEY IRON WORKS SUBSIDIARY: paper-making machinery.

OTHER A-C PRODUCTS: thermal, hydro and atomic electrical genera equipment; switchgear, transformers, unit substations; earth-moving equipm engines, lift trucks.

A-

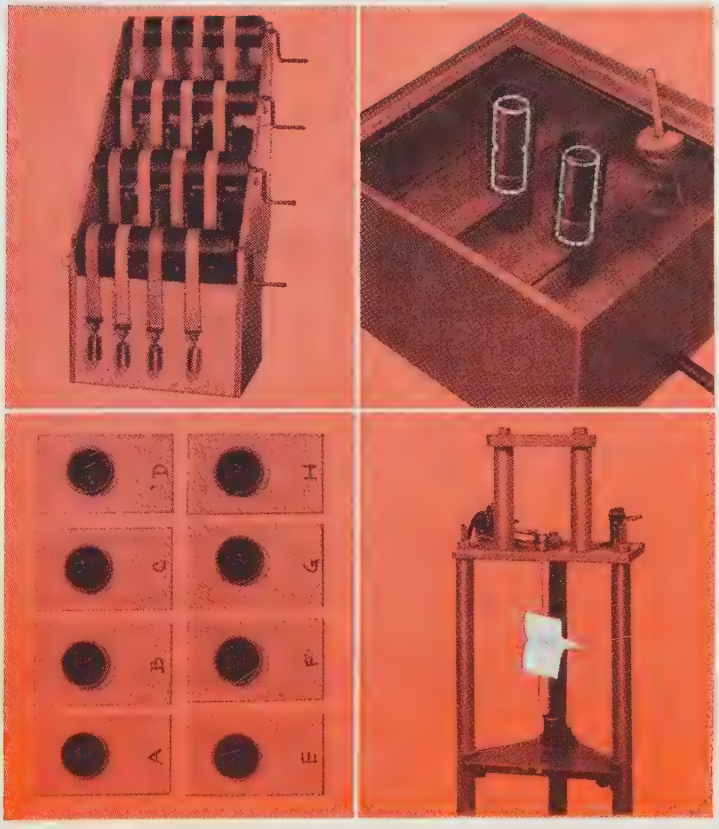
Super-Seal, Poxeal, SpaceMaker and Pyro-Shield are Allis-Chalmers trademarks.

ALLIS-CHALMER

WHICH OF THESE WAX ENDURANCE TESTS WOULD BE MOST HELPFUL TO YOU RIGHT NOW?

In the course of a year, probably all the rugged performance tests shown here could be of some value to you. However, at least one should prove useful in resolving some immediate coating problem. You may, for example, require a wax with a high degree of resistance to oils and greases; or flexibility may be the prime consideration. Quite often, the precise degree to which these characteristics must be present to meet your customer's specifications can best be established by proved laboratory testing methods.

Whatever your paraffin requirements may be, there's almost certainly a practical test for determining the proper wax or waxes to do the job. Your Atlantic Sales Engineer will be happy to give you full information on how our research facilities can be of service to you. In most cases, he can supply on-the-spot assistance based on years of experience in the field. When more specialized information is required, he has the full and prompt assistance of the Atlantic Research Department.



THE FLEX-CRACKING TEST

A new testing device to determine proper wax coatings for low temperature operations. Strips of heavily waxed paper are flexed over standard dowels to measure resistance to cracking at various temperatures. The correct coating will remain flexible under these extreme conditions.

GREASE RESISTANCE TEST

This technique is of particular value to packers of products with high animal or vegetable oil content. The wax-coated stock is placed on a blotter and an oil containing a dye is floated on the surface. Performance is determined by strike-through time and degree of penetration.

UNDERWATER BEAM TEST

The purpose of this test is to establish the durability of waxed corrugated board under load when totally submerged in water. Standard of measurement is the time required to collapse under measured weight and water temperature. The Beam Test can be applied to all grades of waxed corrugated board by varying the test conditions.

SEAL STRENGTH TEST

To establish the adhesive properties of wax seals, the seals are separated by pulling the parts evenly in opposite directions. This Seal Strength Test is of particular importance to processors of bread wraps and other products where wax is the only adhesive.

CHOOSE FROM OUR FULL LINE OF HIGH-QUALITY WAXES TO MEET YOUR COATING NEEDS

Philadelphia, Pa.
Providence, R. I. • Syracuse, N. Y.
Pittsburgh, Pa. • Charlotte, N. C.

ATLANTIC

THE ATLANTIC REFINING COMPANY

A SKILLED HAND IN CHEMISTRY . . . AT WORK FOR YOU

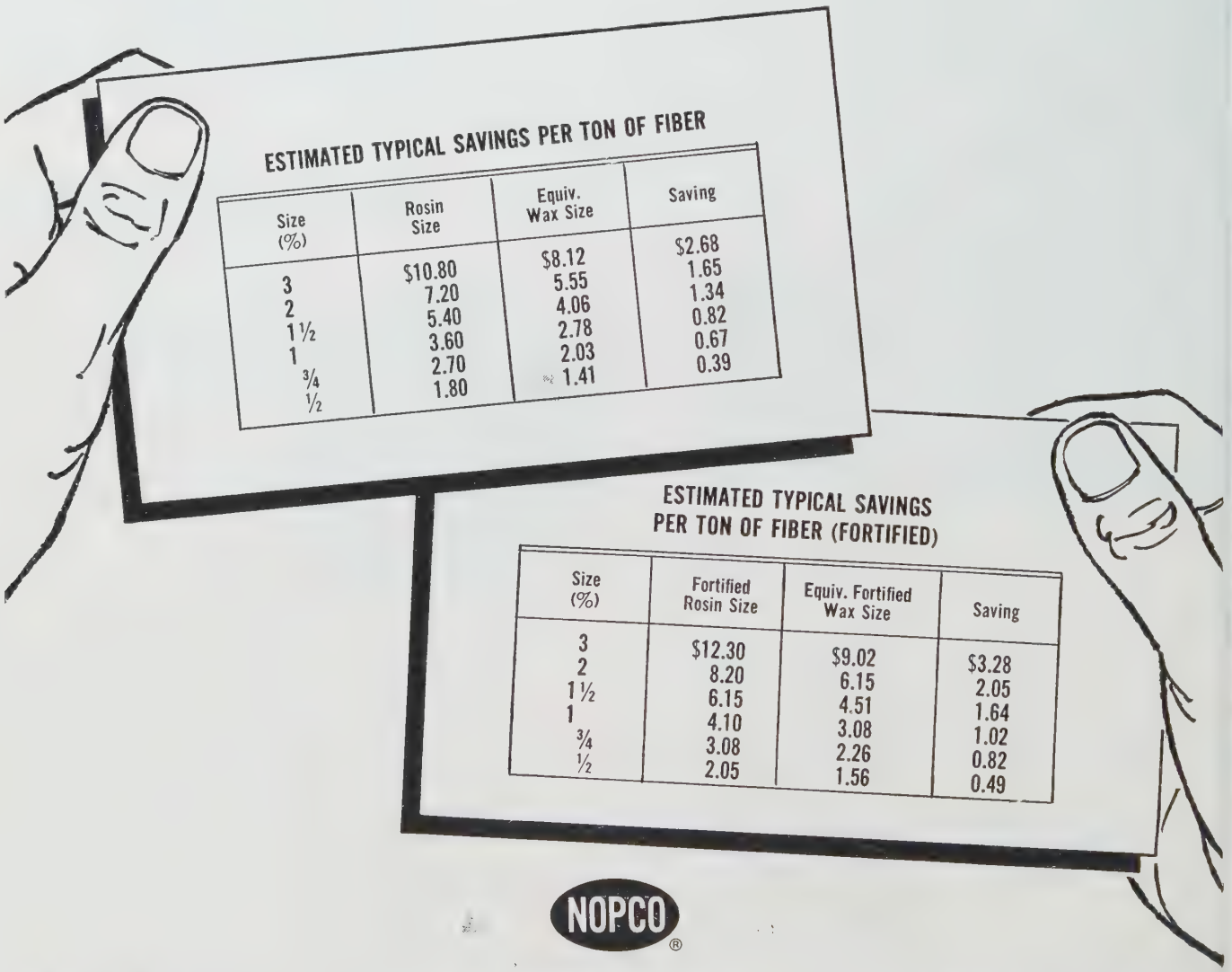
Are your rosin size costs too high?

Nopco® Wax Sizes do more—cost less

Whether your mill uses rosin or fortified-rosin sizes, Nopco can show you how to reduce your sizing costs by using its wax sizes. In addition to saving you money, Nopco Wax Sizes impart improved resistance toward water, ink, lactic acid, alkalis and blood; improve gloss, smoothness and printability; and decreases fuzz, curl and brittleness.

Use of Nopco Wax Sizes in your mill is an advantage you cannot afford to overlook. Let us help you set up a program of tests and trial runs to prove it to your own satisfaction.

Our Technical Service Engineers, utilizing over 30 years' experience with wax sizes, are ready to show you the advantages to be gained by the use of wax sizes in conjunction with rosin sizes. Write today for further information.



ESTIMATED TYPICAL SAVINGS PER TON OF FIBER

Size (%)	Rosin Size	Equiv. Wax Size	Saving
3	$10.80	$8.12	$2.68
2	7.20	5.55	1.65
1½	5.40	4.06	1.34
1	3.60	2.78	0.82
¾	2.70	2.03	0.67
½	1.80	1.41	0.39

ESTIMATED TYPICAL SAVINGS PER TON OF FIBER (FORTIFIED)

Size (%)	Fortified Rosin Size	Equiv. Fortified Wax Size	Saving
3	$12.30	$9.02	$3.28
2	8.20	6.15	2.05
1½	6.15	4.51	1.64
1	4.10	3.08	1.02
¾	3.08	2.26	0.82
½	2.05	1.56	0.49

NOPCO®

NOPCO CHEMICAL COMPANY

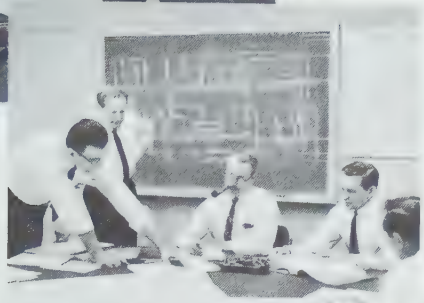
60 Park Place, Newark, New Jersey

Plants: Harrison, N.J. • Carlstadt, N.J. • Richmond, Calif. • Cedartown, Ga. • London, Canada • Mexico, D.F. • Corbeil, France

Manufacturing Licensees Throughout the World

THE SEVEN STEPS OF JONES SYSTEM ENGINEERING

1
Data Gathering



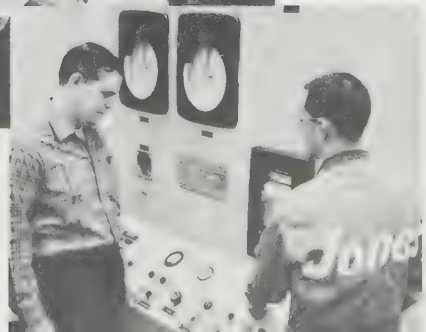
2
Establishing Specifications

3
Laying Out the System

4
Preparing the Proposal and Cost Estimate

5
Detailed Engineering and Supervision of Manufacture

6
Supporting Services



7
Training Mill Personnel and Start-Up of Syste

Step by step, Jones relies on a combination of thorough planning, competent engineering, and teamwork to design and produce stock preparation systems that meet the highest standards of performance and dependability.

THE INTEGRATED STOCK PREPARATION SYSTEM

The next logical step in stock preparation . . .

For a number of years E. D. Jones has been working toward the concept of an *integrated* stock preparation system . . . a system where each separate component works in complete harmony with every other component to function as *one single machine.*

E. D. Jones is now ready to supply paper mills with integrated stock preparation systems, for either modernization programs or completely new mills. Custom designed in conjunction with mill personnel (including their chosen consultants) for specific applications, these systems offer the following unique advantages to forward-looking papermakers:

UNIT RESPONSIBILITY. One source for contract negotiations, liaison during manufacture, start-up assistance, and future systems service.

FASTER PROJECT IMPLEMENTATION, resulting in earlier start-up.

LOW EQUIPMENT COSTS, because major components are selected from the wide range of regularly manufactured Jones equipment — all competitively priced.

LOWER OPERATING COSTS, because of efficient, carefully matched, easy-to-maintain components.

GREATER FLEXIBILITY FOR THE FUTURE, because a JONES system is designed to meet tomorrow's requirements . . . as well as today's.

For further information, write to:

Systems Engineering Group
E. D. Jones Corporation
Pittsfield, Massachusetts

Canadian Associates:
The Alexander Fleck Ltd. • 75 Spencer Street, Ottawa

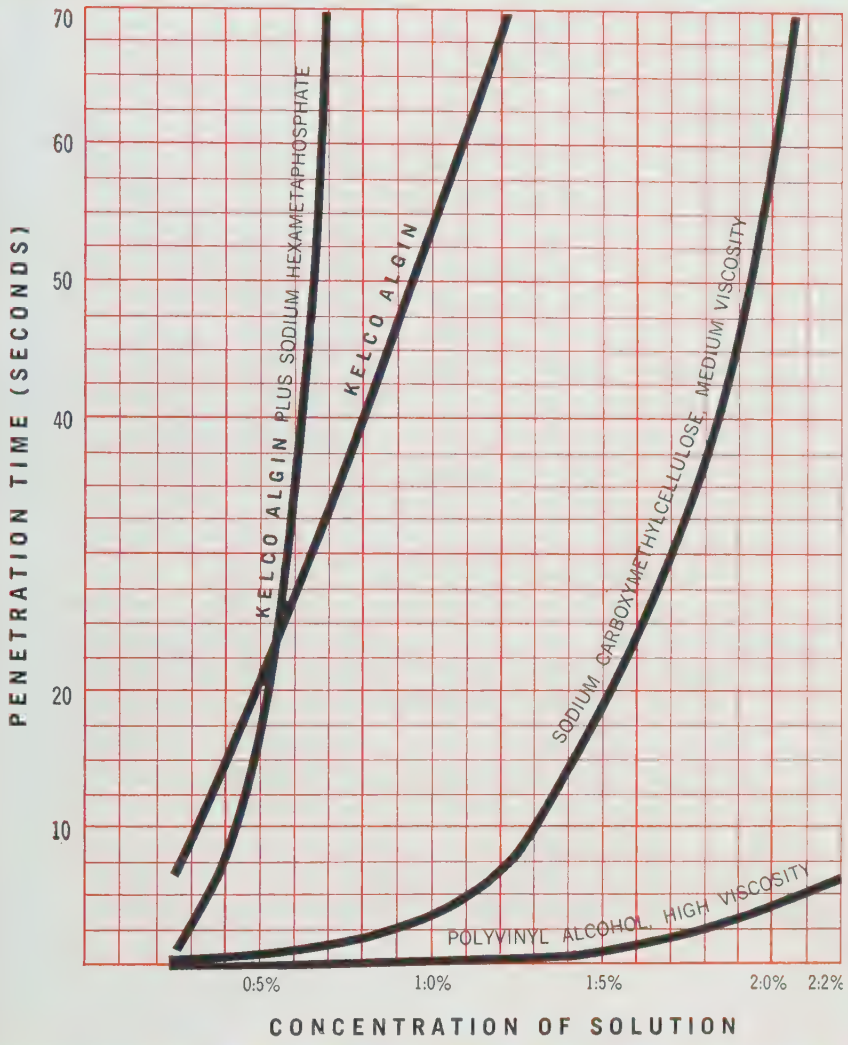
E. D. JONES CORP. PITTSFIELD, MASS. member BELOIT group

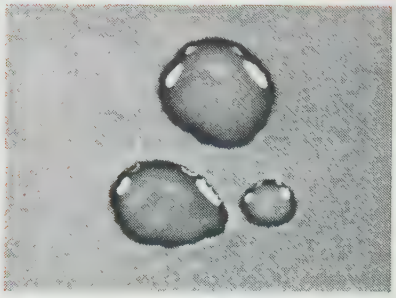
Jones

PULP MILL EQUIPMENT AND STOCK PREPARATION MACHINERY

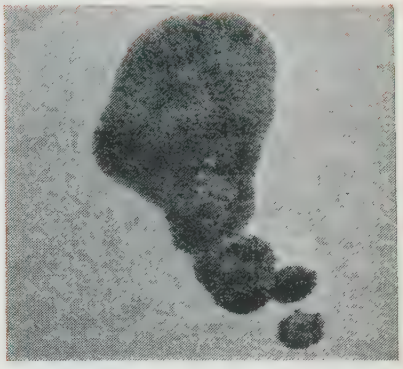
Remarkable! The way Kelco Algins give greater

PENETRATION





This photograph shows a 1% solution of Kelco Algin twenty minutes after being puddled on blotter. Note how algin controls penetration and retains solution on surface of blotter. This test illustrates the outstanding ability of algin to control penetration. With it you can get the exact degree of hold-out desired for sizings, coatings, adhesives, inks, etc.



Here is photograph of water, without algin, on same piece of blotter taken seconds after water was placed on blotter. Note how water passed immediately into blotter compared to controlled penetration of algin solution.

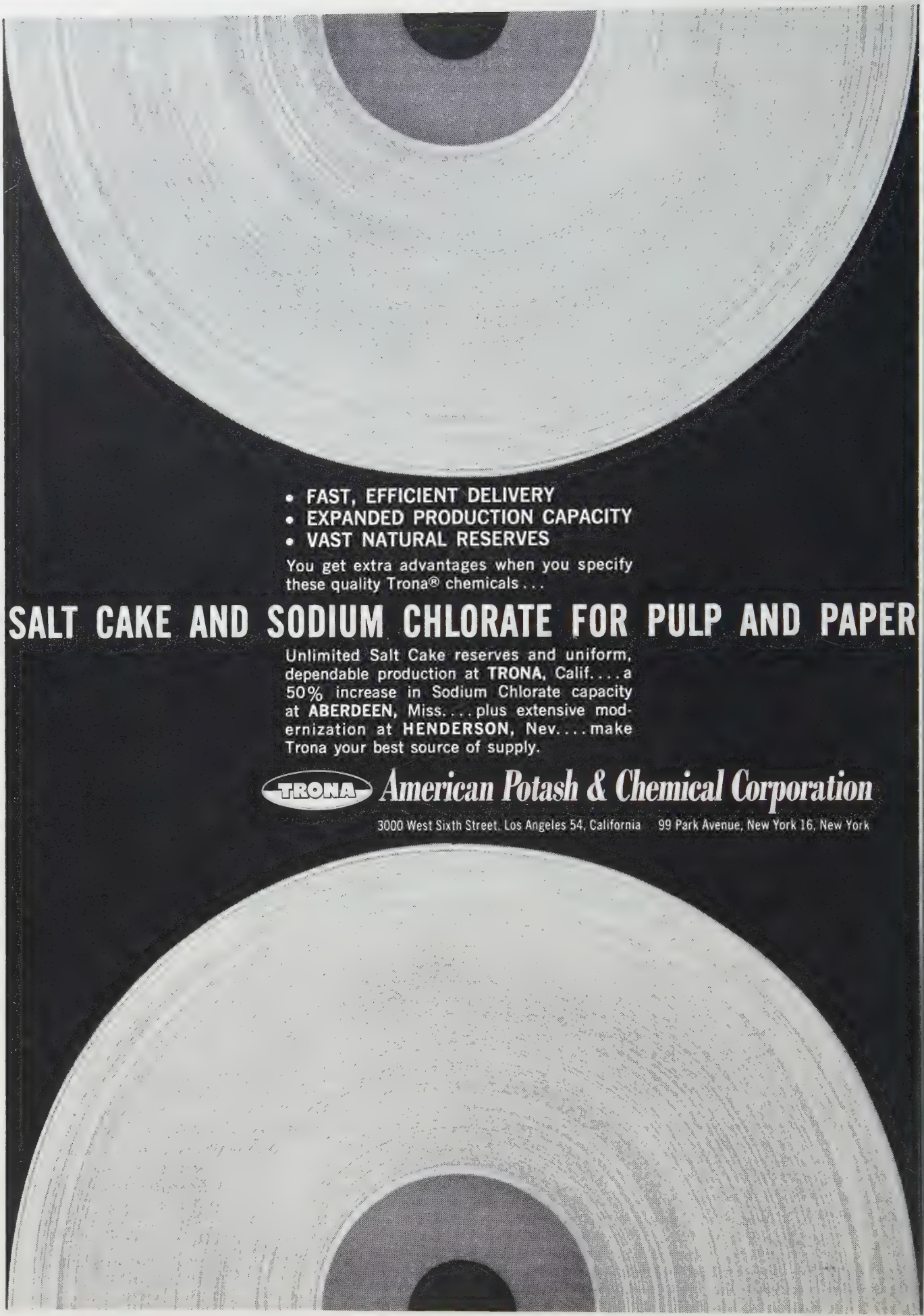
CONTROL

This graph and blotter test illustrate and prove that KELCO ALGIN products are among the most efficient materials available for controlling penetration. By using proper proportions of a product such as KELGIN, KELGIN LV, KELGIN XL or KELSIZE, manufacturers of papér products can regulate the amount of penetration of size formulations, clay and wax coatings, printing inks, adhesives, etc. Of course, having your formulation where you want it, without excessive and unnecessary penetration, saves you money.

MAKE YOUR OWN TEST: Samples, information and technical service, yours on request without obligation.

KELGIN® KELGIN LV KELGIN XL KELSIZE S® products of **KELCO COMPANY**

75 Terminal Avenue, Clark, N. J. • 20 N. Wacker Drive, Chicago 6, Ill. • 530 W. Sixth Street, Los Angeles 14, Calif. Cable Address: KELCOALGIN CLARKNEWJERSEY


• FAST, EFFICIENT DELIVERY
• EXPANDED PRODUCTION CAPACITY
• VAST NATURAL RESERVES
You get extra advantages when you specify these quality Trona® chemicals . . .
SALT CAKE AND SODIUM CHLORATE FOR PULP AND PAPER
Unlimited Salt Cake reserves and uniform, dependable production at TRONA, Calif. . . . a 50% increase in Sodium Chlorate capacity at ABERDEEN, Miss. . . . plus extensive modernization at HENDERSON, Nev. . . . make Trona your best source of supply.
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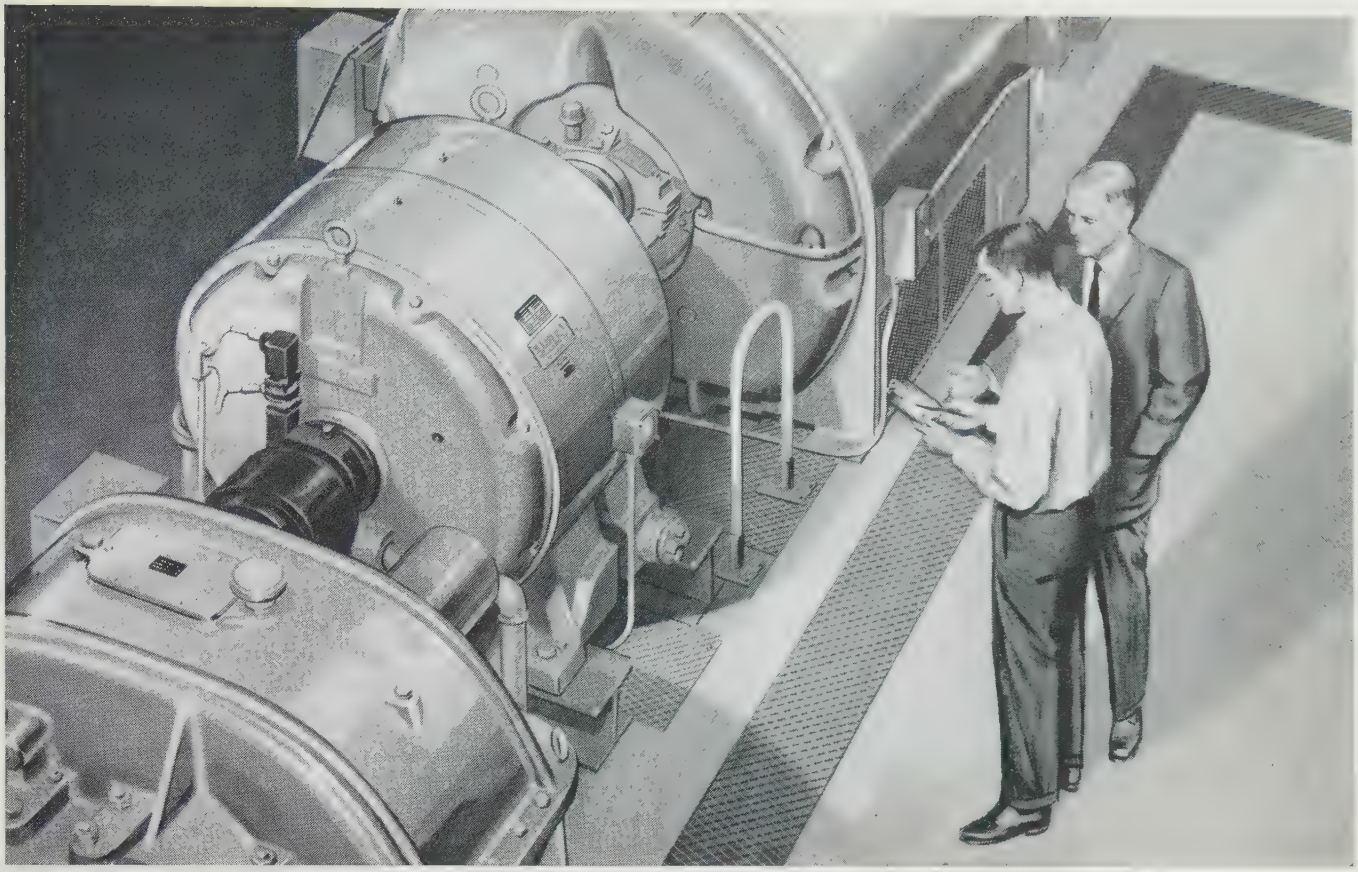


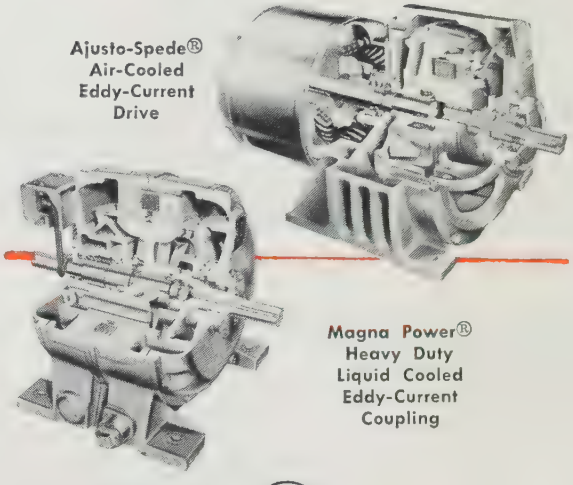
Place Your Speed Control Problems in the Hands of Experts!

As the originator and leading producer of eddy-current speed control equipment, it is only natural that Eaton-Dynamatic offers many exclusive design and construction advancements —plus expert engineering service.

The transmission of torque across an air gap by means of eddy-currents is a fundamental Dynamatic development. It was first utilized 30 years ago, and is today the operating principle of a full line of couplings, brakes, drives, and dynamometers serving industry wherever accurate control of speed and torque is required.

Eddy-current equipment runs on standard AC—requires no special power source. Electronic or transistorized magnetic amplifier controls, engineered and manufactured by Eaton, provide constant speed, infinitely adjustable speeds, and many specialized operating functions.

Representatives, located in all principal cities, are fully qualified to give you expert help with your speed control or torque transmission problems. Call the Eaton-Dynamatic representative nearest you today—there's no obligation.



Ajusto-Spede® Air-Cooled Eddy-Current Drive

Magna Power® Heavy Duty Liquid Cooled Eddy-Current Coupling

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DYNAMATIC DIVISION
MANUFACTURING COMPANY
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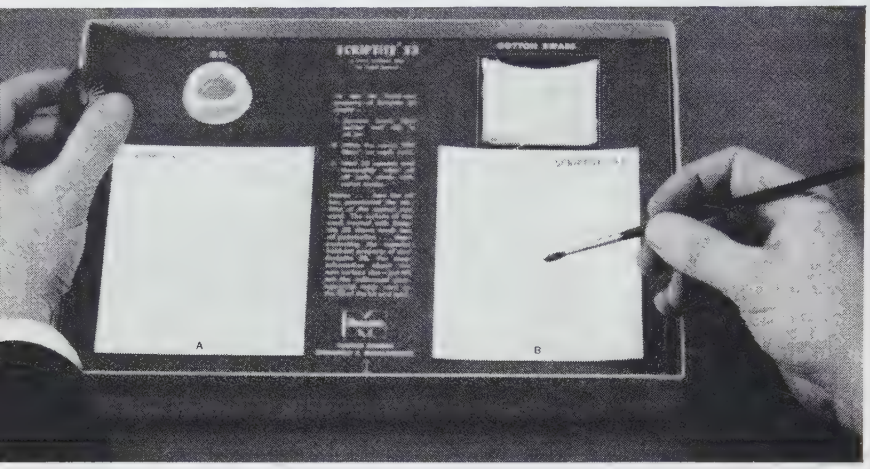
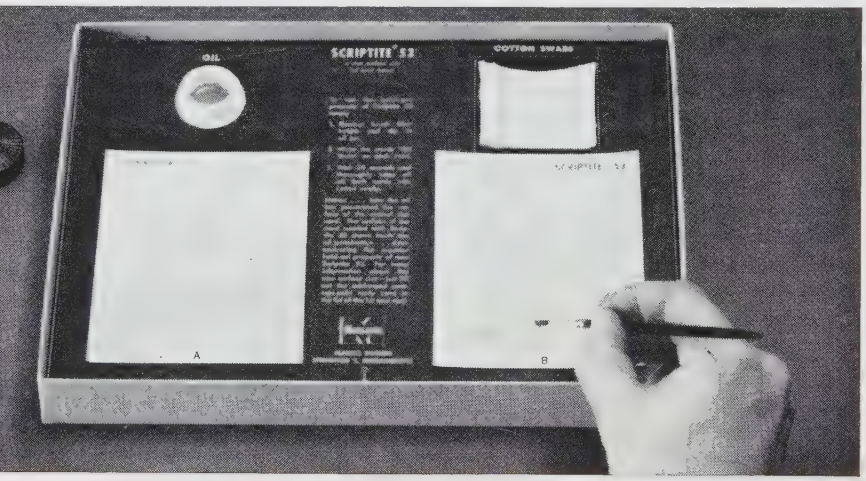
This 30-second test proves the superior hold-out qualities of new

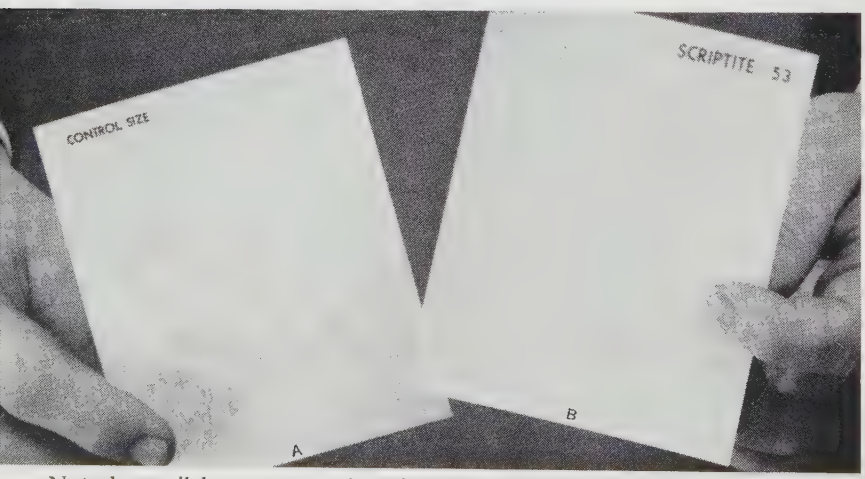
SCRIPTITE® 53



Paperboard A has a starch ether surface size. Paperboard B was treated with new Scriptite 53 surface size.



OIL was brushed on both A and B, allowed to dry 30 seconds, then wiped off.



Note how oil has penetrated surface of card A far more than on card B, demonstrating the superior hold-out property of Scriptite 53. You can make this simple test yourself. Ask your Monsanto representative to show you the special Scriptite 53 test kit.

Food board has clearer, brighter appearance when it has been treated with Scriptite 53. This new Monsanto surface size improves wax hold-out on food board and light waxing grades of paper for packaging and laminating. Scriptite 53 keeps the wax coating evenly distributed on the surface of the board, stopping excessive internal penetration of the coating which gives food board a dull greyness.

Scriptite 53 has particular application for milk container and frozen food board because of its excellent lactic acid resistance. It acts as a barrier to the acid even when wax coating has been penetrated, preventing carton bulge. Scriptite 53 is exempt from regulatory provisions of the Food Additives Amendment by virtue of FDA's confirmation of "No reasonable expectation of migration when used as a wax hold-out resin." For additional data on Scriptite 53 or board samples write Monsanto Chemical Company, Plastics Division, Room 811, Springfield 2, Massachusetts.

Monsanto®

MONSANTO INITIATOR IN **PLASTICS**

NEW Butterfly Valve!

MATCHLESS LUNKENHEIMER QUALITY

FIG. 4026N

Complete Valve with Ends as Casting.
2"-8".
Screwed End.

FIG. 4150N

(Rubber-Lined: Fig. 4151N) Valve Elements Only.
2"-12". Screwed, Welded, Grooved, or Flanged Ends Supplied Separately to Fit Your Pipe Connections.

W. P. 150 psi.

- QUICK OPENING
- POSITIVE CLOSURE
- NICKEL-PLATED CAST IRON
- STAINLESS STEEL TRIM
- "O" RING SEALS

New Lunkenheimer Butterfly Valves are compact and lightweight, easy to install on any line in a fraction of the space required by standard gate or plug valves. A quarter-turn of the stem opens the disc full or closes it tight. No lubrication is required, and "O" Ring seals provide positive shut-off in either vacuum or pressure service. These new Butterfly Valves are made to traditional Lunkenheimer standards of quality. WRITE for new Catalog 613 or call your Lunkenheimer distributor today for full information on the new Lunkenheimer Butterfly Valve line . . . available now for immediate delivery.

L-361-23

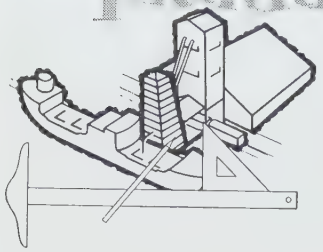
LUNKENHEIMER QUALITY

LUNKENHEIMER®

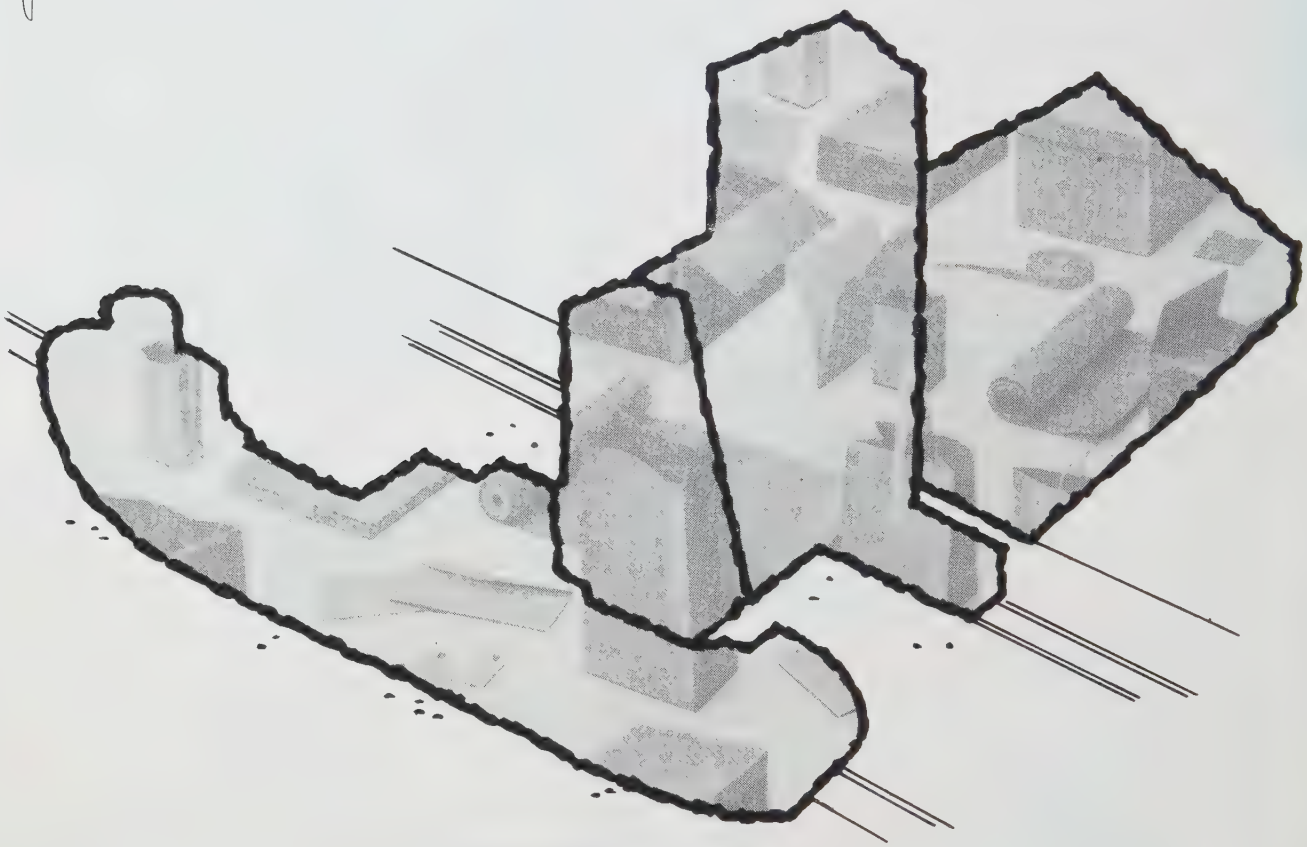
THE ONE *Great* NAME IN VALVES

WEST END

advance planning



OF SALT CAKE STORAGE DEPOT ANTICIPATES INDUSTRY'S GROWING NEEDS



WEST END identity as a prime nationwide supplier of highest quality salt cake is underscored by Stauffer of Canada storage depot . . . the West End project that solved the problems of time and cost of other means of transportation. Customers benefit from reduced inventory requirements, lower transportation costs and prompt delivery.

Stauffer CHEMICALS

WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

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MORDEN NO. 6 REFINER, 150 H.P.
MORDEN BIG NO. 8 REFINER, 300-400 H.P.

The Stock-Maker Refiner's unique reverse-flow cushioning treatment provides good mullen, minimum freeness drop, good tear retention. Morden reverse flow holds a cushion of stock between shell and rotor bars, permitting gentle brushing, combing and fraying of the fibers. Customers report power savings up to 50%. **Detailed information upon request.**

BIG NO. 8 REFINE

300 to 400 H.P., for beating. Simp
flow and filling changes conve
this machine into the Morden Stu
Maker Jordan.

MORDEN STUFF-MAKER JORDAN

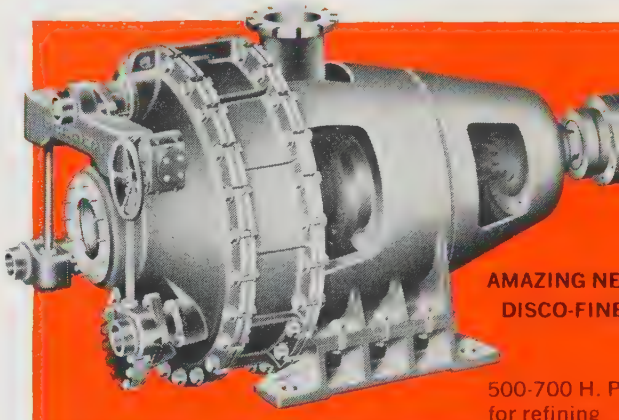
The Morden Stuff-Maker for jordaning represents a real technical advance in Jordan engines. In place of conventional rolled bar fillings, Morden provides precision cast, dynamically balanced fillings which require no grinding in. Technically advanced Morden fillings substantially improve treatment, give service far in excess of conventional rolled bar fillings. **Complete information supplied upon request.**

better stock treatment • lower power consumption • greater production

• MORDEN accomplishes all three

MORDEN DISCO-FINER, 500-700 H.P.

The most significant new development in stock preparation, the NEW MORDEN DISCO-FINER, provides (a) Tremendous capacity, (b) Low power consumption per ton of production. Simple flow and filling changes adapt the Disco-Finer for defibering or refining. The new self-aligning, semi-conical design of rotor and stator plates overcomes possibility of warpage or deflection. Here, truly, is the answer where large production and high precision treatment are required. **Complete information upon request.**



AMAZING NE
DISCO-FINE

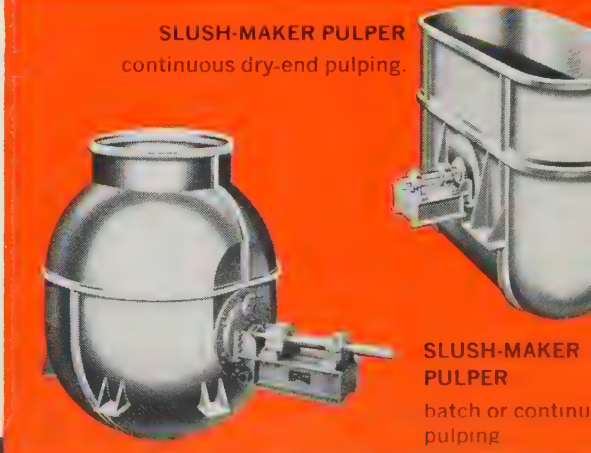
500-700 H. P
for refining
and defiberi

MORDEN SLUSH-MAKER PULPER

CONTINUOUS OR BATCH OPERATION

Regardless of your pulping requirements, there just is no better answer than the Morden Slush-Maker Pulper. It can be employed on continuous or batch operation. Can be mounted beneath the paper machine to handle dry-end broke on a continuous basis at full machine production. Rapid circulation and the unique Morden brushing action give the most thorough repulping. Even where the job is toughest, where space is limited, the Morden Slush-Maker handles pulp sheets, paper stock, coated and uncoated brokes and completely defibers difficult wet-strength brokes. **Write for full story.**

SLUSH-MAKER PULPER
continuous dry-end pulping.



SLUSH-MAKER
PULPER
batch or continu
pulping

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TANKS WILL AUTOMATICALLY COME TO

HAUSER-STANDER
Cincinnati

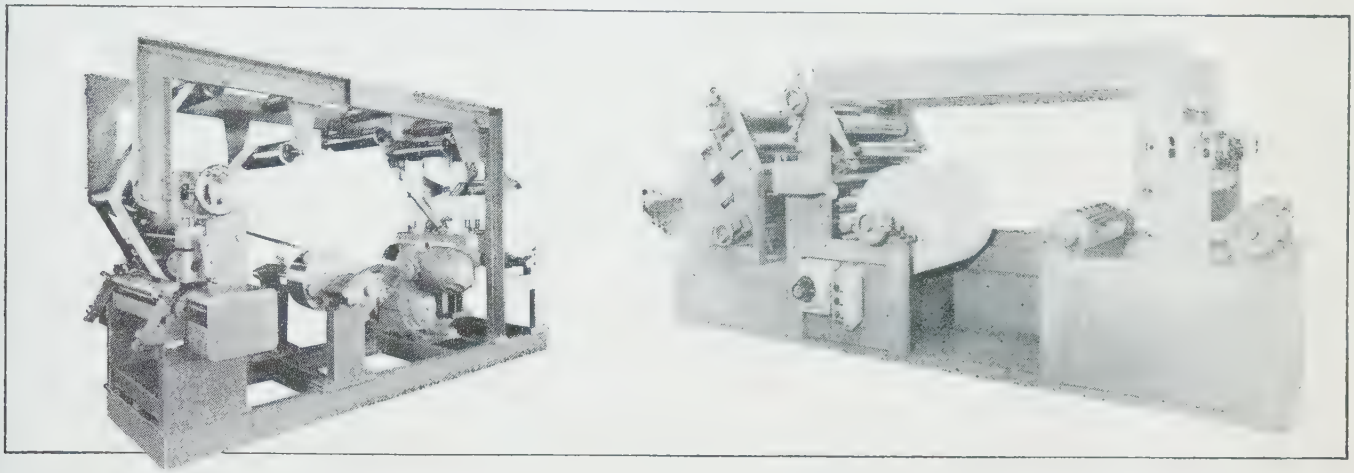
WOOD IS BEST IN CERTAIN
CASES—ASK US WHY.

INTA-ROTO ECONOMY MACHINES

FOR SHORT RUN PRODUCTION OR PILOT LAB

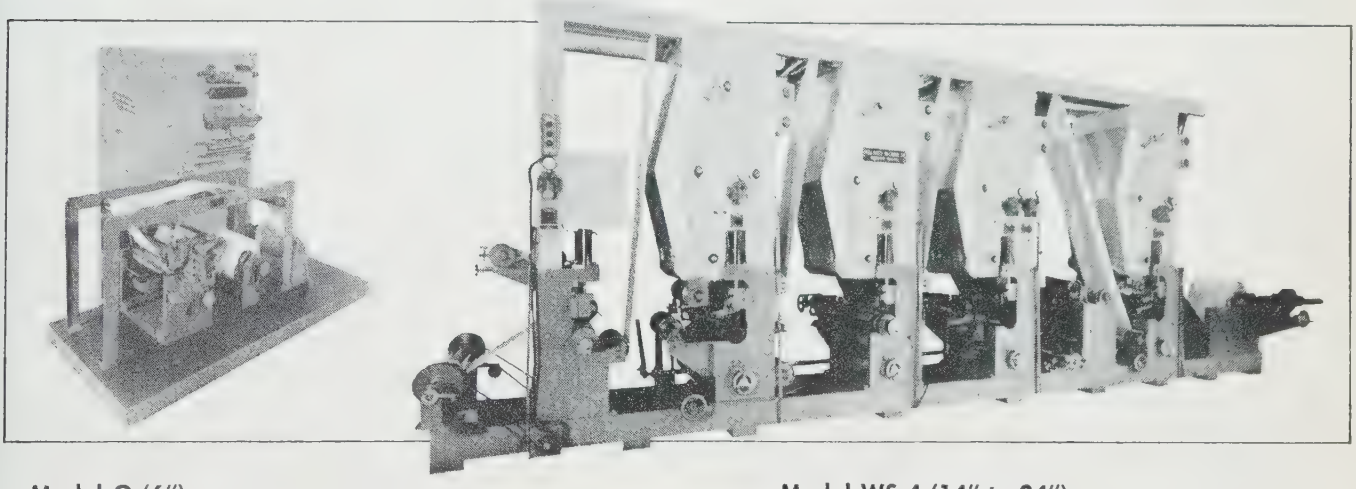
6" to 24" Web Width; for Coloring, Coating, Laminating, Printing; Foil, Film, Paper.

Shown here are only a few of our many laboratory short run machines.



Model RRD (10")
This gravure coater-printer permits the web to be coated on both sides simultaneously, by special threadup and turning bar arrangement. Attachments are available for additional coating methods and for high velocity and high temperature drying.

Model GM-1000 Miniature (14" to 24")
This laminator-coater is a miniature of Inta-Roto's well-known GM-1000 series of high speed production laminators. It laminates with aqueous, wax, or solvent-type adhesives, and coats, colors, treats, or prints, in one pass. Ideal supplement to larger equipment for economical run of small orders.



Model O (6")
Our smallest press for testing gravure and flexographic inks and coatings. Consisting of unwind, flexographic station, overhead web lead to carry web from printing station to rewind. Complete parts for changeover to gravure printing. May be of simplest design merely for pulling a proof, or it may be equipped as a production unit.

Model WS-4 (14" to 24")
Rotogravure press with individual drying hoods for each station, capable of handling a wide variety of materials from unsupported foil to lightweight cardboard. Provisions for aqueous and thermoplastic laminating make this a most versatile machine. Available for pilot or high speed production, with any type of special equipment.

Write or call for more information.

INTA-ROTO MACHINE COMPANY, INC.

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Hydrogen peroxide cotton bleaching time cut 60% . . . that's what Columbia-Southern technical ability linked with knowledge of industry needs developed for the textile trade. Vapor degreasing output boosted to all time high . . . that's an example of results achieved by the combination of Columbia-Southern Trichlor and knowledgeable technical service to the metalworking industry.

Pulp processors, glass manufacturers, leather tanners, petroleum refiners and other producers rely heavily on the service that supports Columbia-Southern Chemicals.

They've learned that this counsel gives them the best mileage on the chemicals they buy. Because of this practical technical assistance, combined with consistently high quality standards and cost-cutting traffic control, discriminating buyers in every industry specify Columbia-Southern Chemicals. You too may profit by doing so.

Chemical Division, Pittsburgh Plate Glass Company, One Gateway Center, Pittsburgh 22, Penna. Offices in principal cities. In Canada: Standard Chemical Limited.

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CHEMICAL DIVISION

PITTSBURGH PLATE GLASS COMPANY

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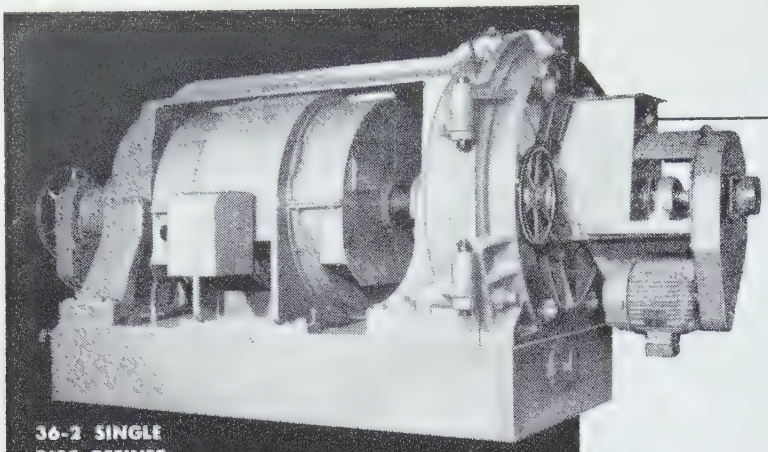
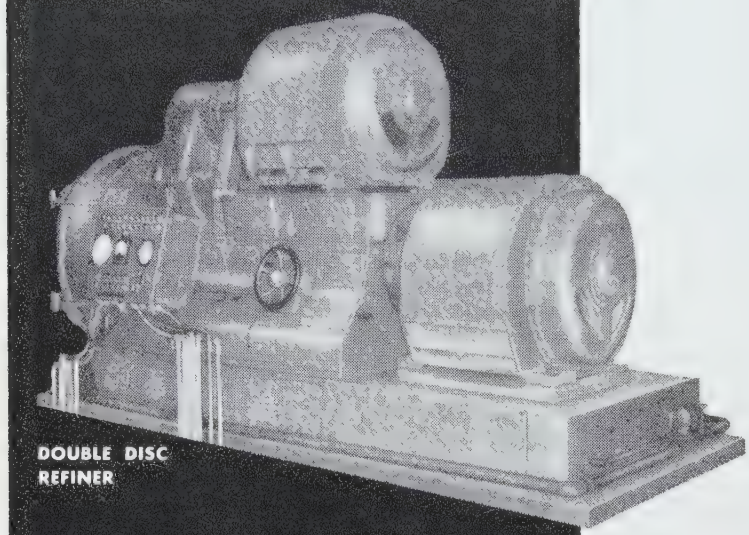
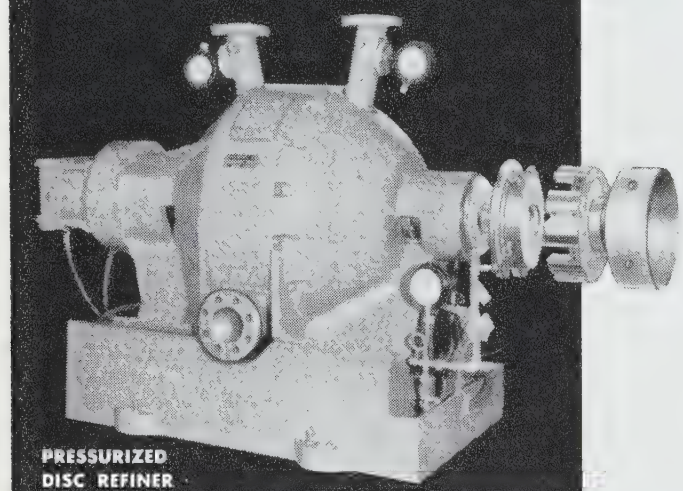
Barium Chemicals • Sulfur Chemicals • Agricultural Chemicals
Reinforcing Pigments • Calcium Chloride • Hydrogen Peroxide
Muriatic Acid • Calcium Hypochlorite • Titanium Tetrachloride



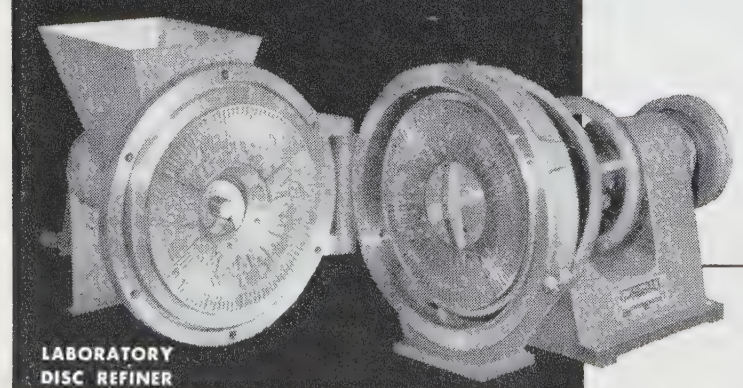
36-2 SINGLE DISC REFINER



DOUBLE DISC REFINER



PRESSURIZED DISC REFINER



LABORATORY DISC REFINER

'SPROUT' REFINERS

THE YARDSTICK FOR THE INDUSTRY

These famous 'Sprouts' are in wide use throughout the world for semi-chemical pulping, bleached and unbleached; high and normal yield kraft stock refining; kraft and sulphate knotter rejects; high yield sulphite; refiner groundwood; groundwood and bull screen rejects; cold caustic pulping; bagasse, flax and straw pulping; insulation and hardboard fiber preparations; wastepaper stock refining; asplund stock secondary fiberizing; rag pulping, and many special processes.

Write for descriptive bulletins.

SW

More Sprout Disc Refiners are sold than any other make

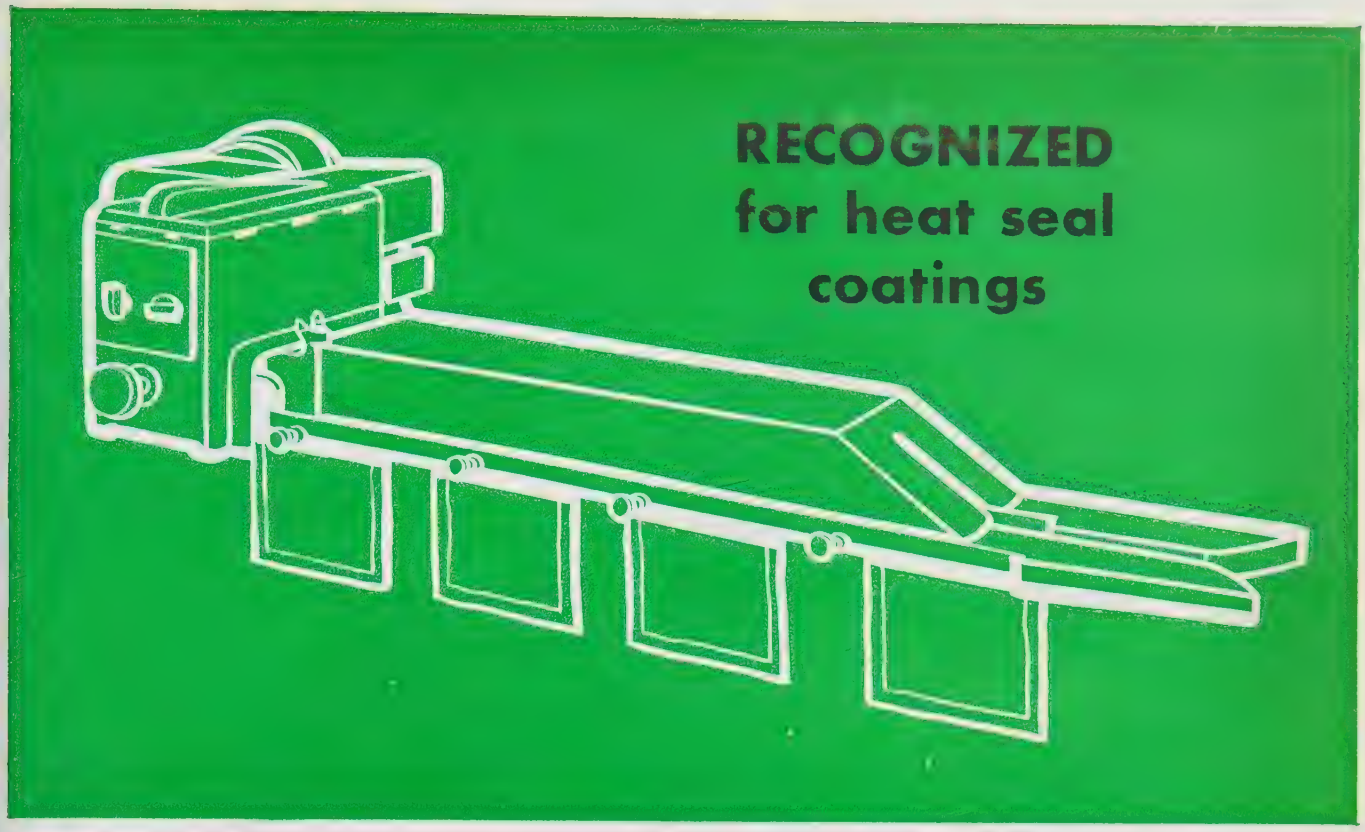
DISC REFINER SPECIALISTS

SPROUT, WALDRON & CO., INC.

MUNCY, PENNSYLVANIA, U.S.A.

Refiners • Conveyors • Feeders • Screens
Mixers • Drainers • Stock Proportioners

633



Gelva® polyvinyl acetate emulsions

GELVA EMULSION PROPERTIES CHART

Type	S-55 Homopolymer Dispersion	TS-22 Homopolymer Dispersion	TS-30 Homopolymer Dispersion	TS-70 Copolymer Dispersion	TS-85 Homopolymer Dispersion	TS-100 Copolymer Dispersion of Vinyl Acetate-Acrylate	C-3 Alkali Soluble Copolymer Dispersion
Total Solids (min.)	55%	55%	55%	55%	54.5%	54.5%	54.5%
Emulsion Viscosity, cps	1100-1300	350-650	1200-1400	900-1300	1400-1700	1000-2000	700-1000
Heat seal temp. of film, °F.	195-205	195-205	200-210	170-180	140-150	180-190	145-155
Mechanical Stability	Excellent	Good	Good	Good	Good	Good	Good
Freeze-Thaw Stability	Very Good	Good	Poor	Very Good	Very Good	Good	Poor

Whether it's a heat seal coating for glassine or for paper . . . or even vinyl chloride, there's a GELVA emulsion for your application.

Excellent adhesion to a wide variety of surfaces, superior compounding stability and machining characteristics, wide solvent tolerance and high bond strength are a few of the important advantages of Shawinigan's GELVA emulsions. The above chart presents physical properties of GELVA emulsions suitable for compounding heat seal coatings.

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Pulp stocks, chemicals
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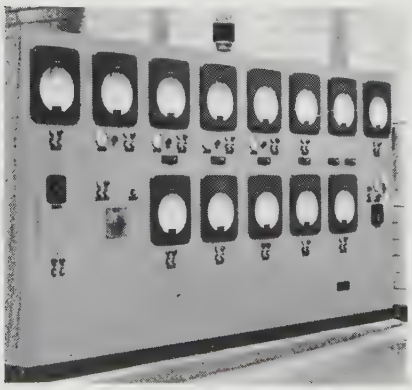
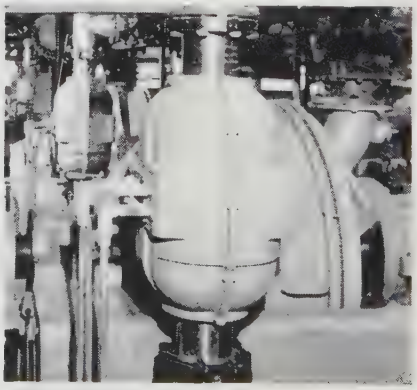
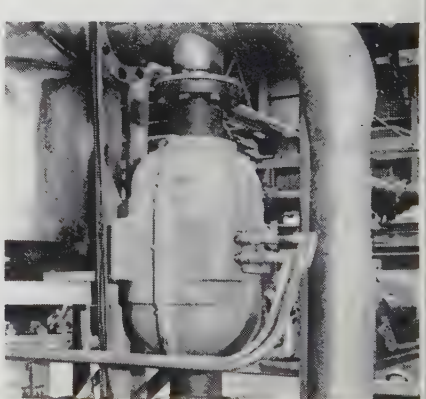
Crown Zellerbach Antioch, Calif. uses Foxboro Magnetic Meters for blending fir and hemlock stocks. Rugged meters are installed outdoors — need no protective housing.



Foxboro Dynalog recorders give operators continuous chart records of the Magnetic Meters linear output. Like the flow meter, Dynalog recorders seldom require maintenance.



St. Regis Paper Company, Jacksonville, Florida. St. Regis uses 5 Foxboro Magnetic Flow Meters in its stock refining system. Meters are 6″ in diameter. System was installed in 1956.



Riegel Paper Corporation, Acme, North Carolina. Riegel has several Magnetic Meters in its mill. The 8″ meter shown above measures broke flow in their pulp stock blending control system.

additives, dyes...
Foxboro Magnetic Flow Meter

hundreds of successful installations reported by America's leading mills

Introduced seven years ago, the Foxboro Magnetic Flow Meter has proved its superiority for measuring the toughest pulp and paper mill liquids. Pulp stocks, mud slurries, starch, liquors all flow right through the meter without plugging up.

That's because the Magnetic Meter has no flow restrictions of any type. No taps to get plugged or frozen, no seals or purges, no moving parts of any kind. Measurement is made by electrodes flush-mounted in corrosion-proof meter wall — then transmitted by electric cable to a Foxboro Dynalog* electronic recorder. System accuracy is ±1%.

Foxboro Magnetic Flow Meters have solved some of the paper industry's toughest measurement problems. Ask your Foxboro field engineer to show how it can help with yours. Or write for Bulletin 20-14. The Foxboro Company, 785 Neponset Avenue, Foxboro, Mass.

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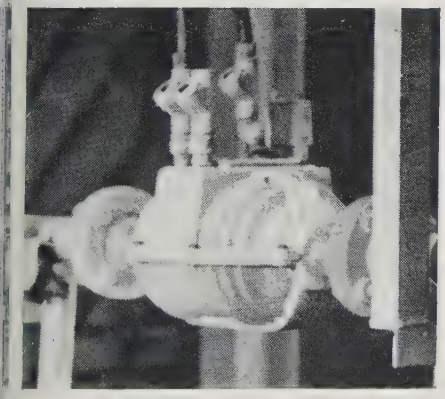
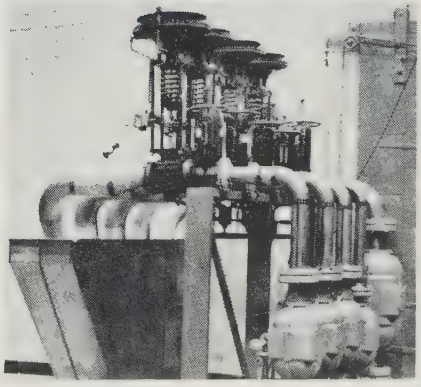
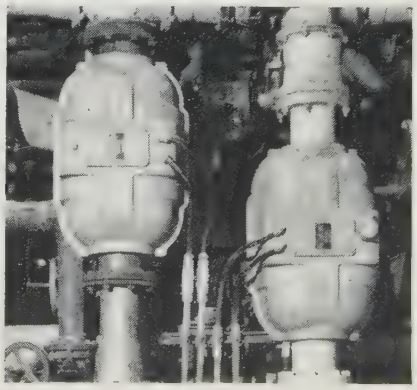


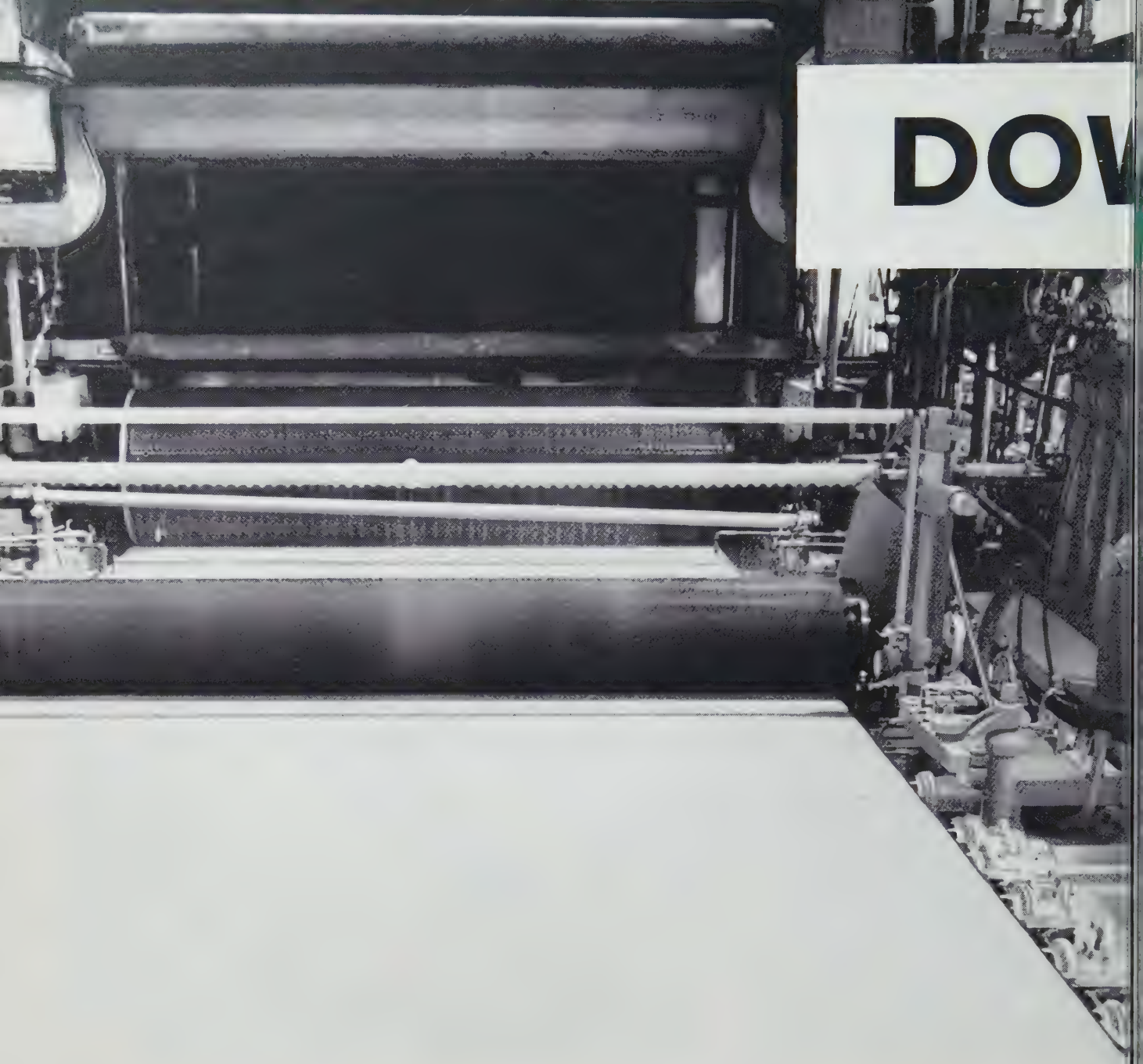
Gulf States Paper Corporation, Demopolis, Ala. Gulf States uses this 2" Magnetic Meter to measure chlorine dioxide flow. This highly corrosive chemical has no effect whatever on the Magnetic Meter.



International Paper Company, Corinth, New York. At International Paper, Foxboro Magnetic Meters allow one operator at a central panel to blend 5 pulp stocks — as well as additives and dyes — accurately and continuously.



Scott Paper Company, Chester, Pa. Scott has a total of 9 Foxboro Magnetic Flow Meters. The first installed on a bleach line over 6 years ago, has required maintenance only once — a new vacuum tube for its Dynalog recorder.



Trial runs can be set up in your plant by Dow technical personnel. For full details, just call your nearest Dow sales office.

paper processing chemicals

SEPARAN POLYMERS

INCREASED RETENTION WITH SEPARAN SAVES $2 TO $15 PER TON IN FILLER COSTS

SEPARAN® NP10 shows a remarkable ability to attach pigments and fillers to cellulose fibers. Applying this property to paper making has resulted in substantial increases in filler retention with savings in valuable pigment and filler costs.

The chart shows typical improvements with several sheet types. The net savings were calculated by subtracting the cost of the Separan NP10 used from the value of the filler saved.

Improved retention decreases the save-all load, headbox consistency, two sidedness, pinholes, wire abrasion and felt plugging. Hence, it contributes to improved formation and better machine operation.

Process water treatment is another area where Separan products can improve operations. Although Separan does not replace primary flocculants such as alum, it does reduce the amount needed. Separan NP10 does, however, act as a secondary coagulant which improves settling rates and clarity in primary water treatment.

Separan products are high molecular weight, water soluble polymers. Solutions can be easily prepared and handled.

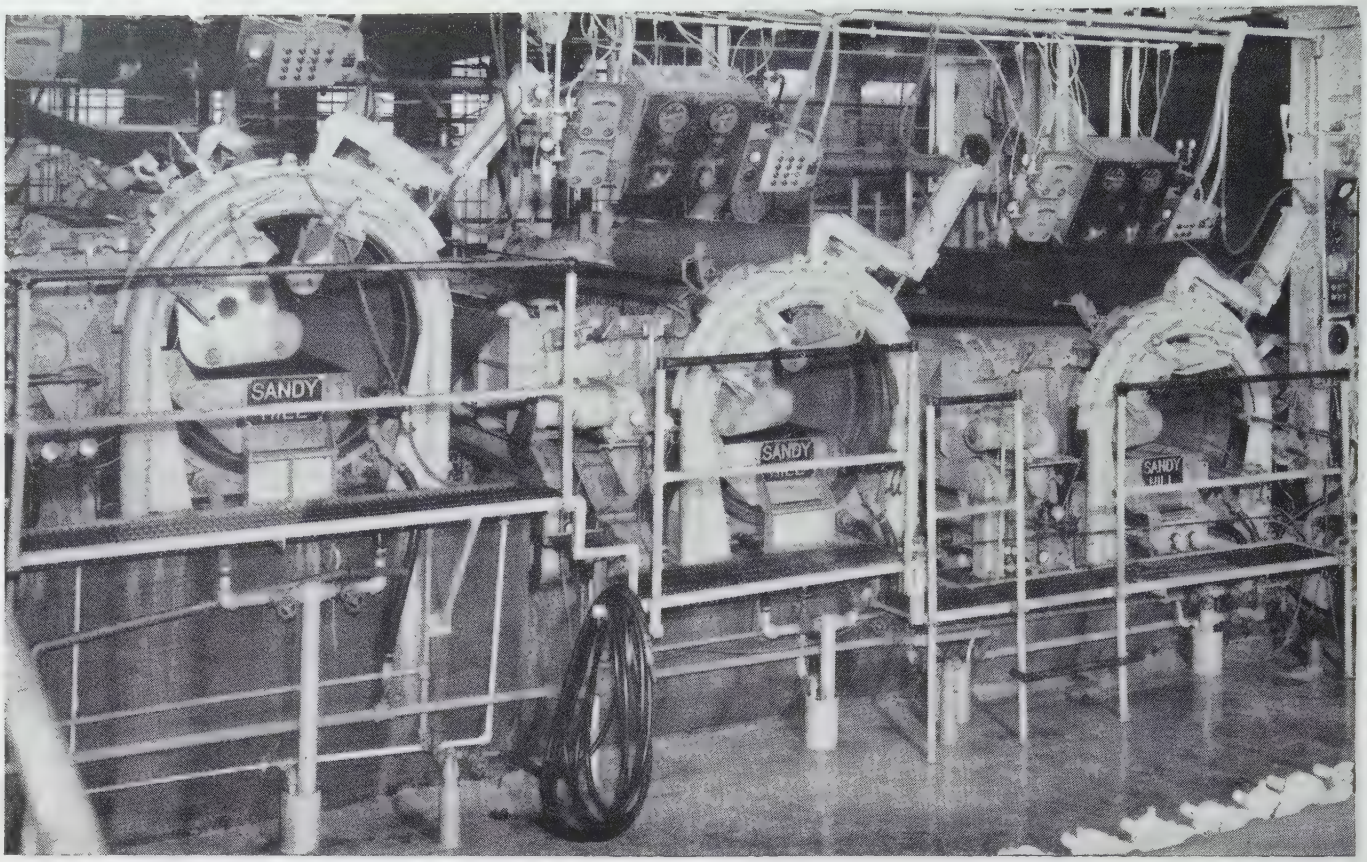
If you are not already using Separan, make an appointment for a trial run in your own plant with technical assistance from Dow. They will furnish proportioning pumps to make the trials convenient and consistent with your present operation. Just call your nearest Dow sales office.

Latest Mill Results	SEPARAN NP10 lb / ton	CLAY lb. / ton	TiO_2 lb. / ton	ASH %	OPACITY %	NET SAVINGS $/ton WITH SEPARAN NP10
55 lb. ENVELOPE	NONE	550	0	7.3	88.0	
	0.5	310	0	10.3	90.2	$4.30
30 lb. MAGAZINE	NONE	600	0	14.8	74.0	
	0.4	375	0	14.1	74.0	$4.10
60 lb. OFFSET BOND	NONE	550	30	12.2	92.0	
	0.5	400	30	13.7	92.0	$2.50
25 lb. MACHINE COATED CARTON WRAP	NONE	50	150	12.2	77.0	
	0.75	50	125	13.2	76.0	$5.50
50 lb. OFFSET BOND	NONE	370	145	9.6	89.0	
	0.6	145	100	12.6	90.5	$15.15

SAVE UP TO $3.50 PER TON ON PEROXIDE, INCREASE BRIGHTNESS WITH VERSENEX 80 IN GROUNDWOOD BLEACH

Using Versenex® 80 chelating agent in combination with hydrogen peroxide in groundwood bleach gives you increased brightness, or you can maintain your present brightness level at lower peroxide concentration. Versenex 80, added to the pulp just prior to the bleach tower, inactivates the heavy metal ions which are mainly responsible for peroxide decomposition. Savings of up to $3.50 per ton in chemical costs are being realized in actual mill operation. For a trial run of Versenex 80 in your own plant, call your nearest Dow sales office.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan



NOW... FIRST MULTI-UNIT ROTOFORMER SET-UP MAKES PAPER-MAKING HISTORY

■ The first 3-unit arrangement of the ROTOFORMER, Sandy Hill's revolutionary papermaking machine, is now in successful use at Sorg Paper Company, Middletown, Ohio. The superiority of the multi-unit Rotoformer over the 5-vat wet end which it replaced is proved through better sheet formation, drier sheet delivery into the press section, space savings, economies in felt life and felt cleaning, simplicity of operation — plus many other advantages. Our new laboratory is ready to show you what the Rotoformer can do for you.

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. . . last one in is a "hydrogen sulfideous"!

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Like to know more about the Betz approach to microbiological control in pulp and paper mills? Bulletin 592 contains the facts. May we send you a copy?

BETZ LABORATORIES, INC. Philadelphia 24, Pa.
BETZ LABORATORIES LTD., Lachine (Montreal), Canada

BETZ
CONSULTANTS ON MICROBIOLOGICAL CONTROL

5 OF THE 19 STEEL STRUCTURES CB&I FURNISHED FOR WARREN'S MUSKEGON, MICHIGAN PULP MILL

ABOVE (bottom to top of photograph)

1. 122-foot waste clarifier
2. 137-foot cone roof water reservoir
3. 190-foot water clarifier

BELOW (left to right in photograph)

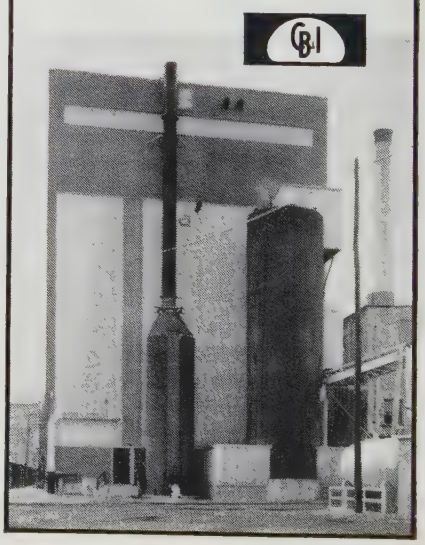
4. 56-foot chlorination tower
5. 40-foot foam tower

Questions of Bigness and Quantity Never Frighten Our Pulp and Paper Experts

Steel clarifiers 190 feet in diameter, steel water reservoirs 137 feet across, towers 57 feet tall—are typical of CB&I storage structures and process equipment at S. D. Warren Company's Muskegon, Michigan pulp mill.

If it is built of steel or alloys, so successfully fabricated by CB&I to combat corrosion, there are few processing and storage structures CB&I doesn't furnish. CB&I design engineers, fabricating craftsmen and erection experts have years of experience in building steel plate work for the industry.

That's why when your quests are for bigger and more efficient storage and processing units to meet your requirements, you should call on CB&I.



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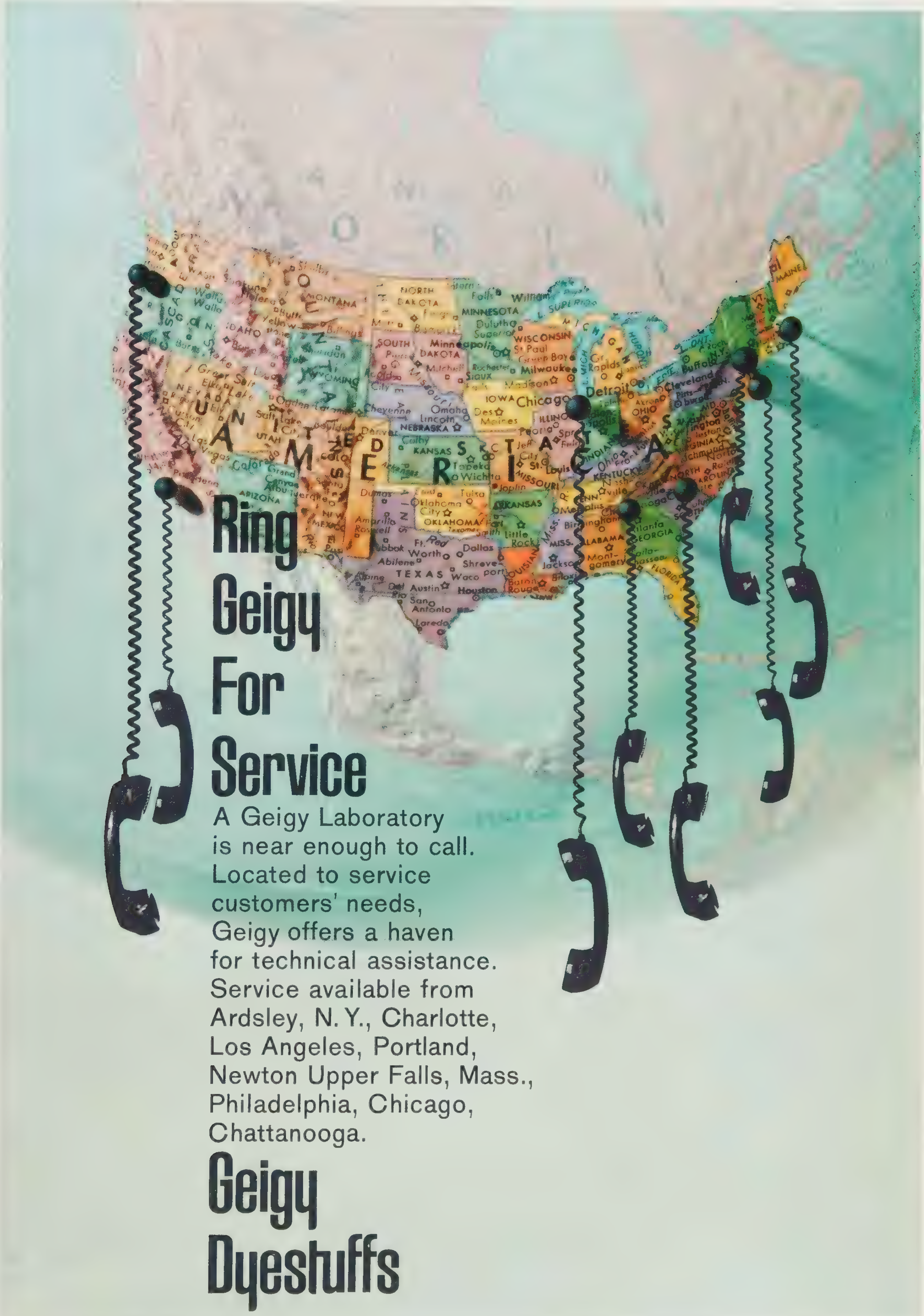
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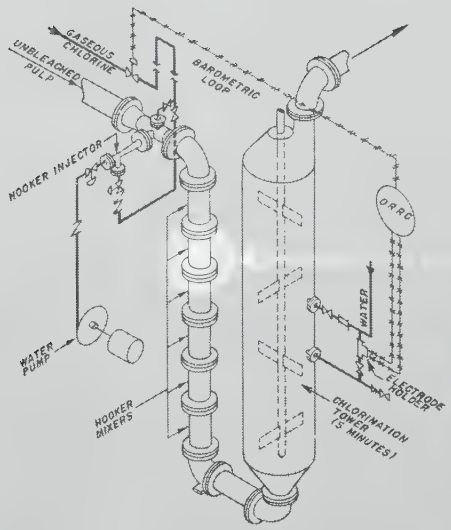
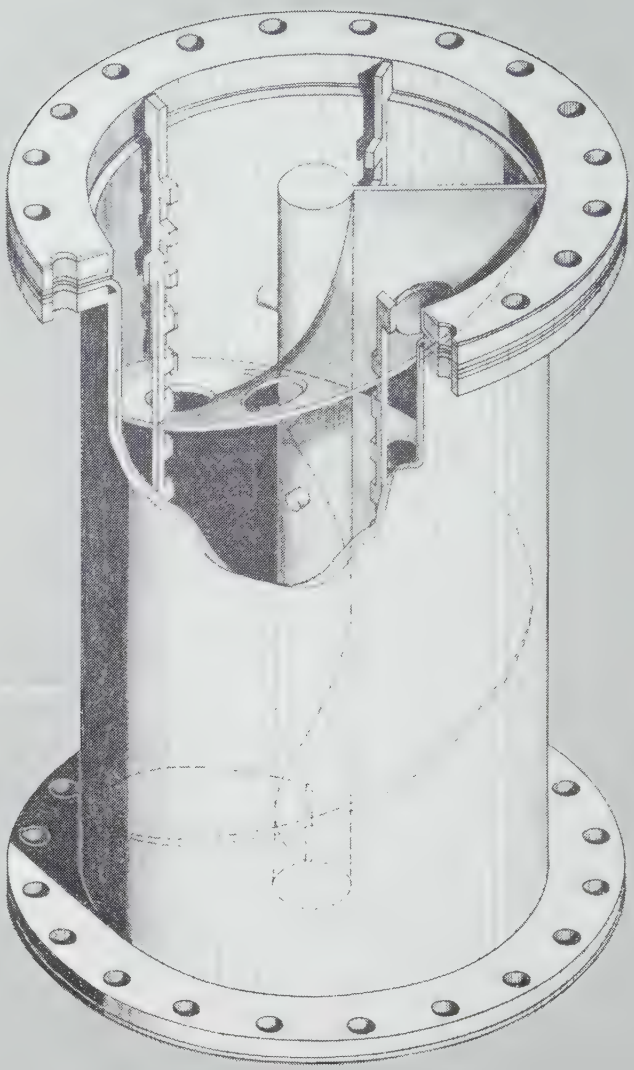


CHLORINE INJECTOR,
MIXER AND REDOX CONTROL



Another step to better pulp chlorination: stock line chlorine-pulp mixing

Now, a different kind of chlorine-pulp mixer—developed with typical Hooker chemagination—puts an end to the guesswork in pulp-chlorine mixing.

This rugged mixer breaks up fiber clumps and distributes the chlorine uniformly throughout the pulp slurry so that each fiber receives the same amount of chlorine.

Thorough mixing with Hooker mixers means higher pulp strength, higher brightness, easier control of subsequent bleaching stages, more uniform pulp quality, and reduced chlorine consumption.

Costs go down and profits go up.

Successful control of chlorine addition by redox potential requires thorough chlorine-pulp mixing. Hooker mixing in combination with Hooker chlorine injection, redox control, and retention-time control adds even more to increased profits.

Hooker technical service engineers will be happy to help you design and install these important components.

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Mechanical Design and Installation Requirements of Trailing Blade Coater Equipment

JOHN P. MUNTON

Increased competition in the coated paper and board industry, and the resulting demand for a better quality product, has increased interest in the trailing blade coater. The trailing blade coater is the most recent development in the field of coated paper. It consists of a rubber-covered backing drum around which the paper is threaded. A flexible steel blade contacts the paper under light pressure, depositing a film of coating. Since the end products of coated papers are many, it is essential that the unit be designed to meet many requirements and continued developments have made this unit adaptable for coating on the paper machine or for high-speed off-machine coating. Refinements to the early blade coater led to the development of an efficient, accurate, and versatile unit, to produce a better quality product.

THE PROCESS of coating paper has created a very competitive segment of the paper industry. In hopes that product improvement can be made, research departments are continually experimenting.

The trend of trailing blade coating resulted from the fact that this process improved the product. Once the technique of operation is acquired, it is simple to operate. Blade coating is a method of extruding a coating on a sheet of paper or board by leading the sheet around a rubber covered backing roll. A thin, flexible blade, supported from a rigid coating head or trough, meters the amount of coating required. The coating head also forms a reservoir for the coating compound. End dykes seal the ends of the trough. Only one side of the paper is coated during this operation. If the paper is to be coated on both sides, the first side is dried and the process repeated on the opposite side. Unlike other methods of coating, the trailing blade does not require a thin coating compound—in fact, coating compounds having high solids content are ideally suited to this process—they reduce the drying requirements and diminish crosswise sheet expansion.

HISTORY

The trailing blade coater was originally thought of as a light weight coater. The first unit was placed in operation to coat breadwrap. This single sided coater handled a maximum web of 196 in. at a top speed of 2000 f.p.m. Following this installation, experiments were made in Worcester showing that a wide variety of coatings could be applied, and with minor improvements on the coater, a considerable range of coating weights could be obtained. Trials were made using types and grades of paper never before coated, with excellent results. In the early 1950's, when this work was being done, the demand for paper was so great that the paper industry could sell its product without having to improve its quality. As competition increased, owing to the rate of expansion in the industry, the demand for improvement in quality stimulated interest in the trailing blade coater.

JOHN P. MUNTON, Chief Engineer, Rice Barton Corp., Worcester, Mass.

REASONS FOR THE POPULARITY OF THE TRAILING BLADE

One of the reasons for the popularity of the trailing blade is that it applies a very light coat, leaving no undesirable pattern due to the splitting of the film. There is neither ribbing nor orange peel, and the coating weight can be as low as 3 lb. per ream. Streaking which occurred on some of the earlier installations was due to:

1. Improper screening.
2. Poor circulation in the coating trough.
3. Damaged or defective blade.
4. Poor housekeeping.

Improper screening and poor circulation have been eliminated by improved design. Items 3 and 4 depend on the individual mill operation, and as is the case with any new piece of equipment, the operators must become acquainted with it.

This coater does not necessitate an elaborate drive, since the coating drum is the only unit requiring an in-drive. The coating head is positioned by means of an a.c. motor. The coating head is moved into position against the drum by a pair of air cylinders.

The coater will operate over a wide speed range. Some units on board machines operate at speeds as low as 250 f.p.m., while conversion coaters on paper operate at speeds in excess of 2500 f.p.m. Originally a conversion unit using this type of coater had to be slowed for splicing; this resulted in a decrease in coat weight. For example, if this machine on the same run is varied from 1500 to 500 f.p.m., the coating weight will decrease about 15%. As speed is increased beyond 1500 f.p.m., the percentage change decreases and at 1800 f.p.m. becomes constant.

Since a paper machine runs at a constant speed, this is not a problem; however, it does exist in a conversion unit. Problems only exist for the engineer to solve. It then became necessary to make splices at speeds of over 2000 f.p.m., and this is currently being done. This enables conversion units to operate at a stable rate so that changes in coat weight are not significant now.

THE FIRST TRAILING BLADE COATER

The initial units were installed for lightweight coatings, but subsequent field checking indicated that much heavier coating weights could be applied. Such details as varying the blade extension, blade thickness, blade angle and position of the blade in relation to the

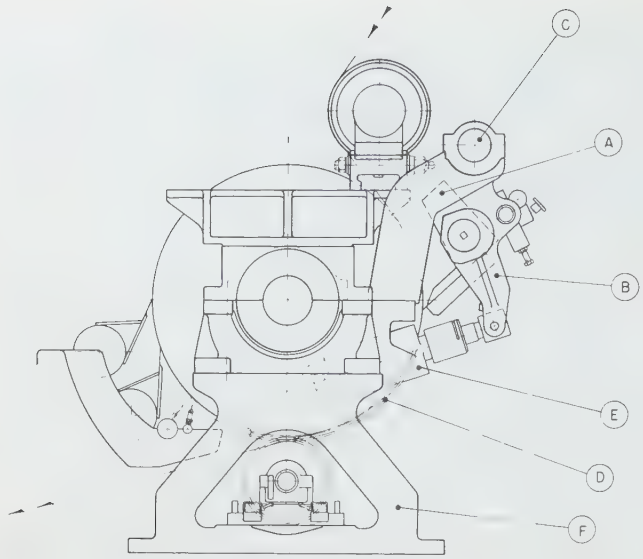

Fig. 1. Trailing blade coater; front end viewed from tending side

horizontal axis of the roll contributed to the improvement of the coating.

The original concept of the blade coater utilized a blade that would contact the roll with a uniform pressure across the entire sheet width. Since the raw stock coming to the coater has certain irregularities, it has been found that minor changes made to the blade at the critical areas would help level the sheet.

Thermal expansion of the coater head was experienced in some of the wider units when placed on the paper machine. This was due to the high ambient temperatures and the radiant heat from the paper driers. Since the coating head is not made of a uniform cross section, thermal expansion will cause the head to bow away from the backing roll. This, in turn, pulled the bottom jaw away from the roll, consequently affecting blade overhang, resulting in an increase in coating weight at the center of the sheet.

THE NEW TRAILING BLADE COATER

In order to advance the art of trailing blade coaters and at the same time to make use of the full potential of the coater, it should have maximum flexibility and a high degree of accuracy. It should operate successfully over a wide range of coat weights and types of paper.

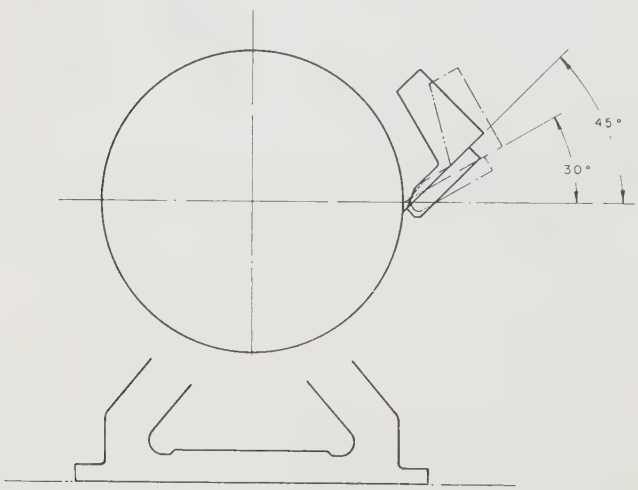

Fig. 2. Coater head blade angle adjustment

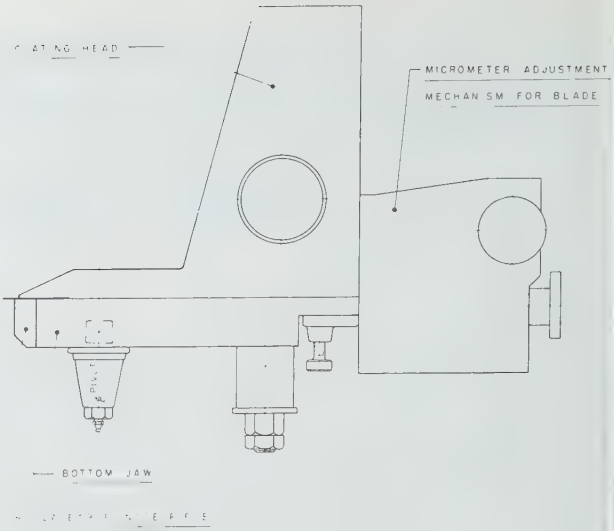

Fig. 3. Coating head assembly

These features were incorporated in a new coater developed in 1959.

Rapid blade changing is necessary as well as quick washup of equipment to increase operating efficiency. The new coater design provides for this. All controls are more readily accessible in the new unit. Full advantage of the experience gained in designing, building, and servicing over 70 coaters was incorporated in this more advanced unit.

Figure 1 shows the newest design coater. The coating head *A* is suspended in two arms *B*, which are in turn keyed to a cross shaft *C*. This shaft is free to rotate and is carried in a pair of bearings mounted on segment *D*. The segments are supported by bearings attached to the housings of the main drum bearings; therefore, any rotation of the segments and any part fastened to them move concentrically with the coating drum.

The segments are driven by gears mounted on a cross shaft. The cross shaft is powered by an electric motor operating through a gear reducer. This equipment serves to raise the coating head from the lower or dump positions to the horizontal operating position. Experience shows that varying the position of the blade and the head, either above or below the horizontal center line of the roll may be beneficial.

The coating head *A* is supported by journals in the swing arms *B* and is free to rotate through a 15° angle. The exact position is maintained by adjusting screws which locate the head through the 15° range. The coating blade will contact the roll from a position 30° to 45° from the horizontal center line.

The coating head is brought into contact with the drum by means of cylinders *E*. These cylinders are mounted on the base frames *F* with the rod end connected to the arms *B*. The head has cross wise positioning so that, should the position of the sheet change on the drum, the end dykes can be easily reset (Fig. 2).

In the retracted position the head is about 4 in. away from the roll so that there is no interference with the sheet when threading the coater of high speeds. It can be either in the dump or raised position while threading.

Special care goes into the manufacture of the head. The steel weldment is stress relieved, then rough machined, then mechanically stress relieved, finish

machined, and chrome-plated. The stainless steel weldments which were used in some installations have been replaced by chrome-plated weldments as they have less tendency to distort from stress and are easier to machine. Chrome plating is much easier to keep clean. The bottom jaw and blade holder are manufactured out of the same material and finished in the same manner as the coating head. A separate piece of stainless steel is used for the leading edge. In the event of mechanical damage in service, this piece can be replaced or remachined, whichever is necessary. If thermal distortion should occur, the leading edge can be adjusted (Fig. 3).

End Dykes

On the early coaters the end dykes were crude. An improperly set dyke could score the roll or allow leakage at the blade. As adjustment was difficult, this resulted in machine downtime. A number of materials have been used as dykes and presently a specially treated felt is being used to seal the trough. The felt can be adjusted so that just the right amount of pressure is held against the blade, the sheet and the coating head. The dykes are supported rigidly by the coating head but can be moved to accommodate changes in sheet width.

Circulation of Coating

Proper circulation of the coating is necessary to secure the best results. A typical arrangement is as follows. Coating is fed from a storage tank, through a screen, into a constant level supply tank. A pump forces the coating into a supply header attached to the coating head. From the supply header coating enters the trough at two or more points, usually located just inside the end dyke. A bleed-off from the end of the coating header returns to the screen, making the flow continuous. The overflow is taken off at two points located near the center of the head and returns to the screens.

When the paper is being coated at speeds 700 f.p.m. and over, the color is agitated by the paper to such an extent that the circulation rate can be decreased. Machines running at lower speeds need a higher circulation rate to compensate for the speed.

Liquid level control in the head is obtained by manually-operated valves or adjustable speed pump motors. Small fluctuations in the coating level do not affect the coating.

Cleaning Doctors

Soon after the installation of blades coaters, it was apparent that on lightweight sheets the bleed-through caused a buildup on the roll, affecting the coated sheet. Sheet breaks ahead of the coater resulted in a deposit. A shower followed by cleaning doctors, or wipers, will keep the roll clean and dry. The wipers are controlled by a selector switch that allows them

1. To be used continuously.
2. To be used manually.
3. To be used automatically when a sheet break occurs; in this case, it is triggered by an electric eye or similar device.

Coating Blades

Originally coating blades were furnished with a square edge, allowing them to wear in, in service. When this was done there was a gradual improvement in the coated sheet until the blade was broken in. While this was not important with some grades of paper, it was a serious factor on others. Time could be saved if the blades were preground to the exact angle. A specially built grinder was made for this purpose. The blade angle is checked optically before removing from the grinder.

Carbon steel, stainless steel, bronze and chromium-plated steel blades have been used with the carbon steel blade possessing the best qualities. Bronze does not have the proper spring qualities; stainless does not wear with a clean sharp edge; and chromium plating is unreliable on such thin blades. Blade life of 24 to 30 hr. on units running over 1500 f.p.m. is quite common with carbon steel.

Care must be taken in handling the blades as this can be the most serious cause of streaks in the coating. The edge of the blade must be protected. Care must be exercised when removing a worn blade, these become razor sharp in service.

On-Machine Coaters

When a trailing blade coater is installed on the machine, the paper leads should be as straight as possible and all reversals gradual. The rope carrier sheaves that contact the paper must be wide and shallow to prevent breaking the tail. Draw rolls should be installed to help the ropes pull the paper. Vertical leads should be kept short to prevent the paper slipping in the ropes. When the coaters are not in use they can be by-passed by using a set of carrier ropes located on the back side of the machine.

OFF-MACHINE VS. ON-MACHINE COATERS

The question of whether to put coaters on or off the paper machine cannot be answered categorically. Each situation must be valued individually. On the basis of investment, the advantage is in favor of on-machine coating, since there is no need of an unwinder or automatic splicer, and the existing reel can be used; however, we are limited to the speed of the machine and downtime on the machine effects the efficiency of the coater. Similarly downtime on the coater lowers the paper machine efficiency. Off-machine trailing blade coaters are operating at speeds of 2000 to 2500 f.p.m. and are being built to operate mechanically at speeds of 3000 f.p.m. It is, therefore, sound judgment in operating a paper machine at top speed and maximum efficiency to use a conversion unit. Both units can then operate a peak efficiency. Paper from more than one paper machine can be handled on the same coater Machines making board operate at lower speeds, and they are well suited to on-machine coating with little loss in efficiency.

SUMMARY

In summary, the new trailing blade coater features the following: (1) heavier design; (2) simplified blade handling; (3) more accurate blade control; (4) improved end dykes; (5) improved coating feed arrangement; (6) simplified controls; (7) greater range of head positioning and blade angle; (8) possibility of heavier coat weights; (9) more uniform quality; (10)

lower startup time; (11) handles splices at high speeds

Because of these features the new coater assures dependable results on a wider range of products.

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Crown Control of Paper Calenders

M. D. STONE and A. T. LIEBERT

This paper discusses the problems of obtaining the proper total crown for varying nip pressures, temperatures, speeds, etc., and focuses attention on a new development in the field of paper calendering. This development places in the hands of the operator, the ability to vary the crown of the king roll (and also the top roll—independently) practically over the full range, as different types of products with varying requirements as to loading, etc. are calendered. The method is to bend the king roll (or the top roll) by a hydromechanical system, which can be varied practically instantaneously, as desired. This technique has been in successful use for several years in rubber calendars by the Adamson-United Co., a subsidiary of United Engineering & Foundry Co. In addition, the paper gives equations for determining total crown, and formulas for required "true" crown, including the contribution of shear to roll deflection, and a description of how such true crown curves, i.e., crown shape, as contrasted to center magnitudes only, can be obtained by grinding with adjustable partial-cosine-curve crowning attachments.

STATUS OF PAPER CALENDER DESIGN

The calendering of paper as we know it today followed by only 30 years the history-making invention in 1798 by Nicolas-Louis Robert, in Paris, of the continuous, mechanical making of paper "on an endless wire cloth, which retained the matted fibers." Up until this time, and from the first manufacture of paper from an aqueous suspension of pulp from rags, wood bark, etc., in China about the year 100 A.D., the batch method held sway for some 1700 years. Neither Robert, in France, nor his licensees in England, the Fourdrinier Brothers, benefited commercially from their pioneering efforts—but the era of continuous papermaking was well on its way within 15 years. The first fourdrinier machine in the U.S.A. was imported in 1827, built by B. Donkin; and in 1829, the first domestic-built fourdrinier was built in Connecticut by the Smith, Winchester Co.—which machine was reported still in operation some 15 years ago (*1*, *2*).

The first known patent for "polishing" paper between a pair of calenders or rolls was granted to T. Gilpin, of Philadelphia, in 1830, who was also a pioneer in the cylinder type of papermaking machine—and it was reported that calendering was practiced in England during this same year. Supercalendering was developed sometime later, around 1850—the inventor and exact date not being known (*3*). An important contemporary development that made both of these machines possible, was the accurate grinding of iron rolls, especially chilled iron rolls, which were found to be superior for calenders because of their hardness and wear-resistant qualities. Barclay was granted the first patent, in Great Britain, in 1842, for the bonded grinding wheel, made from corundum (flours of emery) and clay (*4*). Emery is a natural aluminum oxide, and was far superior to the older grindstones (made from sandstone), when properly made into a wheel, for the cylindrical grinding of rolls. And J. Morton Poole, of Wilmington, Del., about this same time invented and patented the dual, opposed wheel paper mill roll grinder (*4*)—that made possible the practical production of smooth, accurate, hard rolls, necessary to continuous production calendering of web stock. The Lobdell Car Wheel Co., also of Wilmington, Del., founded in 1836 as manufacturers of chilled iron car wheels, became a natural supplier of chilled iron rolls for the paper industry, and later took over the Poole grinder, which remains the basic calender roll grinder of today. In 1949, United Engineering and Foundry Co. took over the Lobdell Co., and is now a major supplier of calender rolls and rolls for all types of paper machinery, paper mill roll grinders, calenders, etc.

By 1873, when Carl Hofmann wrote his classic treatise on papermaking (*5*), both the machine calender and the supercalender were well-established papermaking machines, remaining so, of course, up to the present. It is more than pertinent to quote Hofmann's descriptions and explanations of these machines:

"The calenders consist mostly of iron rolls placed in a stack or nest. The object of the calendering operation is to compress the web, and especially its surface, so that the pores or hollow spaces between the fibers will be filled up, and the whole mass solidified. Paper, like other materials polished in a similar manner, acquires thereby a smooth, glossy appearance. To produce a uniform sheet, it is necessary that the rolls should fit perfectly on one another, and that their surfaces be true and smooth. If the light shines through between the rolls, while they are standing or running empty, it is an evidence that they are not true; if their surface is rough, they cannot be expected to give a smooth one to the paper; and in neither case are they fit for the duty allotted to them. Their polishing power is proportional to their weight or pressure; they are therefore made heavy, and weights on a leverage, or screws, are brought to bear on the upper roll. . . . If they exercise too heavy a pressure on the ends, the calender rolls must spring up in the middle and become useless. If all the rolls are cast solid, and the top one is made very large (not less than 12 to 15 in. diamter), the necessity for extra pressure on the ends is entirely avoided. The bottom roll carries and moves the entire stack, and is entitled to the same or a larger diameter than the top one; but all rolls between the two may be varied to suit the intentions and views of the manufacturer. . . . Three, four, or seven rolls about 8 to 9, 6 to 7, or 5 in. diameter respectively, between the top and bottom ones, will answer in most cases. . . . Whenever the paper passes between the rolls, it is subjected to the polishing pressure; the greater the number of rolls, the more effective is the stack; on the other hand, very small rolls have little weight, and cannot exercise the same pressure as the large ones; but their smaller and sharper circles act more acutely upon the paper. . . . The paper is always led in on top and out at the bottom, because the pressure should increase as it advances, and in this way one more roll is added to the weight of every preceding pair."

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Paper machines at this time were not wider than 96 in., and ran at maximum speeds of 125 f.p.m. As to supercalenders for continuous paper web, Hofmann had these things to say:

"Web supercalenders are composed of chilled iron and paper rolls. . . . The two bottom rolls, the top roll, and the third roll (counting from above) are of chilled iron, and the second and fourth rolls are paper. A heavy roll is required on top to give pressure by its weight. The paper rolls must be large, because they would otherwise soon become too small through wear and tear and consequent grinding and turning, and the bottom roll must be strong and large to support the weight of the whole stack. The paper rolls are frequently damaged by the doubling or rolling upon them of pieces of paper, or by accidents, and show high and hollow places, which mark the paper. It is not desirable to turn them off when they are slightly damaged; and it is for this reason that the last two bottom rolls are of chilled iron. The paper passes through them after it has gone over all the paper ones, and their hard surfaces, under the pressure of the whole stack and the screws smooth out again any marks which may have been made by the slightly damaged paper rolls. . . . Supercalenders are built narrow, not over 36 to 42 in., for the width of one sheet only; while the paper machine makes two or three trains of sheet at one time. It is certainly possible to add supercalenders directly to the paper machine, but long rolls would be required, which could hardly fail to spring in the middle if sufficiently pressed on the ends. They would also be more liable to be injured in the paper machine, as they cannot be stopped so suddenly and watched so closely, nor could they run as fast as in an independent stack. . . . The paper calender rolls require frequent grinding or buffing. This can be done while they are running, by an attachment to the frame, which carries an emery roll, moving laterally while being pressed against the calender-roll and revolving with a different speed. The grinding-roll is an ordinary flanged pulley, the face of which is covered with a paste of resin and flours of emery."

At the risk of having labored these points, we have quoted at some length the design and operating features of calenders of some 85 years ago—for not only do they describe well the principles of these machines, but they point up as well the close similarities to present-day machines and the absence of basic changes up to this time. More detailed descriptions and discussions of present-day machine calenders and supercalenders may be had by referring to recent papers by Liebert (*6*) and Thomas (*7*). At the present time, of course, machine calenders are being made with face widths up to 340 in., bottom (king) rolls diameters up to 44 in., maximum nip pressures up to 700 lb. per in. of width, and speeds up to 3000 f.p.m. Supercalender widths have reached 240 in., maximum nip pressures 4000 lb. per in., and maximum speeds on narrower machines up to 5000 f.p.m.

CALENDER ROLL CROWNS

The primary operating problems in calenders still revolve around obtaining the proper total crowns and crown curves under all operating conditions of nip pressure, temperature, speed, etc.—so that a uniform product may be obtained, without tears or buckles, without nonuniformity of paper thickness across the width, etc. Total pressure on the king roll, and top roll nip pressure, are the main conditions that determine the proper crowns on the king and top rolls, respectively. As paper widths have become wider and nip pressures greater, the problems of proper total crowns and crown curves have become more difficult. The more exact determination of the proper crowns has only received the attention of engineers in the past 20 years or so, as discussed in papers by Smith (*8*), and Garrett (*9*), and Gough (*10*). However, even in these

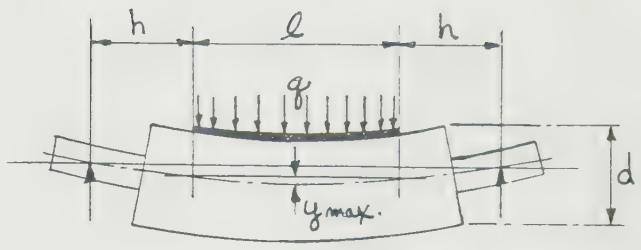

Fig. 1. Nomenclature of deflected bottom roll

studies, the contribution of shear to roll deflection has been neglected, which may amount to as much as 10% in some cases—a not insignificant amount. The most correct expression for the total deflection, i.e., the deflection at the center of the roll with respect to the edges of the web is derived in Appendix A, and is given as (referring to Fig. 1):

$$y_{max.} = \frac{5ql^4}{384EI}\left[1 + \frac{24}{5}\left(\frac{h}{l}\right) + 2\left(\frac{d}{l}\right)^2\right] \qquad (1)$$

where

q = total nip pressure on king roll plus weight of king roll divided by l,
l = web width, in.
E = effective modulus of elasticity of iron roll, 20×10^6 p.s.i.
I = moment of inertia of roll body ($\pi/64d^4$), in.^{4}
d = diameter of roll body, in.
h = roll neck "overhang," i.e., distance from centerline of neck bearing to edge of web, in.

If the roll has a central hole, the value of I is corrected accordingly. The value of E is taken as 20×10^6 p.s.i., based on a number of calender stack studies—being a median or equivalent value between 15×10^6 p.s.i. for the central gray iron and 23×10^6 p.s.i. for the shell chilled iron. The first term within the square bracket represents bending due to the uniformly distributed load; the second term is due to the "overhang" of the neck bearing; and the third term is the deflection due to shear. The magnitude of this latter term is usually around 5% in the average calender roll, but can reach 10%, and represents a closer evaluation of total roll crown than has been utilized to date, including Gough's (*10*) excellent study of this subject. It is significant to mention in passing that for other types of industrial rolls, such as rolling mill backup rolls, this effect may represent a 100% increase over that due to bending alone. The proper total crown on the king roll is, of course, twice this value—for diametral crown.

An appreciation of the values of total crown, and the significance of the contribution of the several components is important. Let us consider a relatively small calender, having a king roll 25 in. diameter, 125 in. body length, and 12 in. overhang whose weight would be around 18,000 lb. The weight contribution to linear loading for a 120-in. wide web would be 150 lb. per in., which in addition to a maximum nip pressure of 350 lb. per in., would result in a maximum value of q of 500 lb. per in. The maximum required crown would then be:

$$\text{Crown (on diam.)} = 2 \times \frac{5 \times 500 \times \overline{120}^4}{384 \times 20 \times 10^4 \times 19{,}000}\left[1 + \frac{24}{5} \times \frac{12}{120} + 2\left(\frac{25}{\overline{120}}\right)^2\right]$$

$$= 0.0072\ [1.00 + 0.48 + 0.09]$$

$$= 0.0112 \text{ in.}$$

If the nip pressure were reduced to 150 lb. per in., the required crown would be 0.0067 in. So that if the operator continued to operate with the original crown, he would be 0.0112 − 0.0067 = 0.0035 in. too high in the center, and obtain a very poor product. From the above calculation, it is seen that 64% of the roll deflection is due to distributed load, 30% due to overhang, and 6% due to snear. We now look at a wide calender, having a 45-in. diameter king roll, with a body length of 325 in., a bearing overhang of 20 in., weighing 150,000 lb., and processing a 320-in. wide web. The linear weight contribution is 470 lb. per in., and taking a maximum nip pressure of 530 lb. per in., we shall calculate the crown for a maximum of value of 1000 lb. per in. Thus:

$$\text{Crown (on diam.)} = 2 \times \frac{5 \times 1000 \times \overline{320}^4}{384 \times 20 \times 10^6 \times 200{,}000} \left[1 + \frac{24}{5} \times \frac{20}{320} + 2\left(\frac{45}{320}\right)^2\right]$$

$$= 0.0690\ [1.00 + 0.30 + 0.04]$$

$$= 0.092 \text{ in.}$$

In this case, if the nip pressure were reduced to 130 lb. per in., the crown would be 0.037 in. too much, as the required crown would be 0.055 in.

For calendering very thin, high quality paper, such as 30-lb. English bond, etc., not only is total crown important, but also the distribution of crown along the entire length of the roll body, i.e., the shape of the deflection curve assumes a considerable importance. For theoretically perfect operation it is desired that the rolling pressure be uniform across the sheet, and the objective in grinding a crown is to exactly offset the deflection of the roll at every point across the width in order to achieve this condition. As has been mentioned earlier, we are not concerned with the total deflection of the roll with respect to the bearings, nor even with respect to the roll ends, but with respect to the edges of the web.

IMPORTANCE OF CROWN SHAPE

In Appendix A is given the development of equation (2) for the "true" deflection curve of a king roll:

$$y = \frac{5ql^4}{384EI}\left\{\left[1 + \frac{24}{5}\left(\frac{h}{l}\right) + 2\left(\frac{d}{l}\right)^2\right] - 8\left[\frac{3}{5} + \frac{12}{5}\left(\frac{h}{l}\right) + \left(\frac{d}{l}\right)^2\right]\left(\frac{x}{l}\right)^2 + \frac{16}{5}\left(\frac{x}{l}\right)^4\right\} \quad (2)$$

The notation is the same as that in equation (1), where x is the distance from the centerline of the roll to any point, having a maximum value of $l/2$ at the edges of the web. In examining equation (2), which is the "true" deflection curve of the roll under ideal conditions, we observe that the effect of overhang is introduced through the h/l terms; and the effect of shear, through the d/l terms. The remaining terms reflect the bending of the roll body due to distributed load alone. Further, the curve is not a parabola or a circle, as is very often assumed, since it has a 4th-order term. However, for a wide variety of king roll designs, the shapes of the deflection curves are closely identical, as shown in Table I, where we have tabulated $y/y_{max.}$ vs. x/l for the two cases discussed previously plus a third one, 30 in. diameter by 170 in. long, with a 12½ in. overhang and a 165 in. web width. Table I also shows the parabolic or circular deflection curve (they are closely identical—to within $^1/_{10,000}$ of 1%, and hence need not be differentiated). The comparison shows the maximum deviation to be 0.0373 at $x/l = 0.35$; i.e., about one-fifth of the way in from the end of the roll. If we were dealing with a calender roll whose maximum crown was 0.050 in. on diameter, then the maximum deviation would be 0.0373 × 0.050 = 0.0019 in. This is a considerable amount, corresponding to a variation from the true crown of 7.5%; and it is to be also noted that the crown would be 10.5% off at the one-tenth point. This comparison, in general, shows that if the roll were ground with a parabolic crown, the resultant paper product would develop "soft spots" on the paper winder at one-tenth to one-fifth of the way in from each end, due to a below-caliper product at these locations.

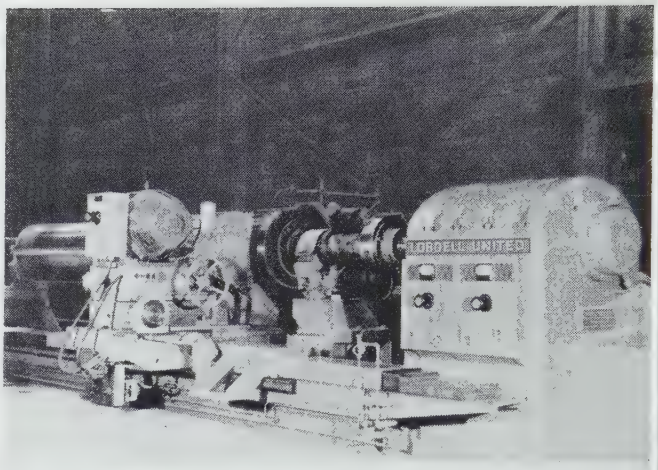

Fig. 2. Modern roll grinder with partial-cosine-curve crown mechanism

GRINDING OF CROWN SHAPES

The problem of grinding the proper contour on a king roll is very much a matter of a properly designed crowning mechanism being incorporated in the roll grinder. In the early days, roll grinder manufacturers used cam plates or "sine" bars that controlled the position of the grinder wheel head directly, but they proved not too practical since every diameter and length of roll and magnitude of crown, required a different cam. More recent grinders have used cam- or eccentric-tilted

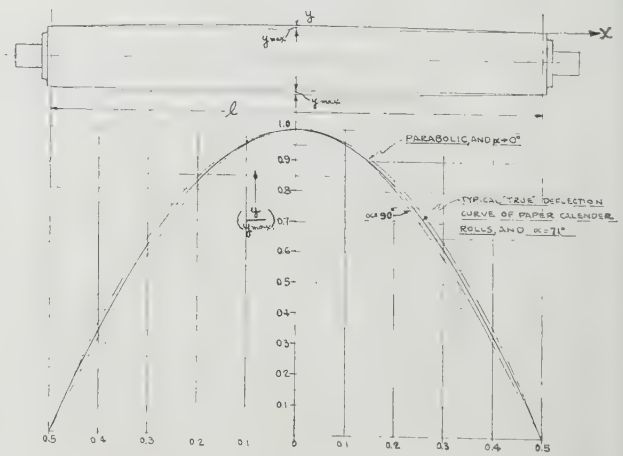

Fig. 3. Comparison of roll deflection curves and crown shapes

Table I. Comparison of "True" Deflection Curves and Parabolic Curve

x/l	$y/y_{max.}$ $d = 25$ in., $l = 120$ in., $h = 12$ in.	$d = 30$ in., $l = 165$ in., $h = 18^1/_2$ in.	$d = 45$ in., $l = 320$ in., $h = 20$ in.	Parabolic crown	Max. deviation	% Deviation
0	1.0000	1.0000	1.0000	1.0000	0.0000	0.0
0.1	0.9557	0.9549	0.9542	0.9600	0.0058	0.1
0.2	0.8249	0.8222	0.8198	0.8400	0.0202	2.5
0.3	0.6141	0.6095	0.6054	0.6400	0.0346	5.7
0.4	0.3341	0.3295	0.3256	0.3600	0.0344	10.5
0.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0

wheelhead carriages, where the eccentric arc or angle bore a fixed relationship to the length of roll, creating a cosine-type contour. The most recent type of grinders, such as is shown in Fig. 2, provides change gears in the crowning mechanism so that any selected part of a cosine curve may be fitted to any and all lengths of rolls; thus not only permitting a variety of crown shapes, but providing a means of fitting the crown or contour to the exact shape of the "true" deflection curves.

As is shown in Appendix B, the equation for the shape of any general partial-cosine-crown curve, may be written as

$$y = y_{max.}\left[\frac{\cos\theta - \cos\alpha}{1 - \cos\alpha}\right]$$

$$= y_{max.}\left[\frac{\cos(2\alpha x/l - \cos\alpha}{1 - \cos\alpha}\right] \qquad (3)$$

where

$\pm\alpha$ = maximum angular rotation of eccentric or crank for roll length, l

θ = any intermediate angular position of crank, corresponding to $\theta = (2\alpha/l)\,x$, where x and l are as defined previously

Referring to Figs. 10 and 11 a more detailed appreciation of the significance of these matters can be had. We can now see how grinder crown shapes can be varied as desired by simply varying the maximum crank angle $\pm\alpha$, corresponding to any required roll body length l. In the Table II, we have shown a variety of such crown shapes corresponding to $\alpha = 45°$, 71°, 90°, and for $\alpha \to 0$. As angle $\alpha \to 0$, we get the "fullest" crown, which approaches the parabolic crown shape. $\alpha = 90°$ corresponds to a true cosine-curve crown, which is the "shallowest" crown shape in which we might be interested. By comparing this range of possible crown shapes, with the shapes of "true" deflection curves given earlier we see, as is shown in Fig. 3, how any deflection curve may be closely matched along the entire body length. For the typical deflection curve of paper calender rolls, as shown in Table I, we see that $\alpha = 71°$ is the proper crank angle to use for any roll body length.

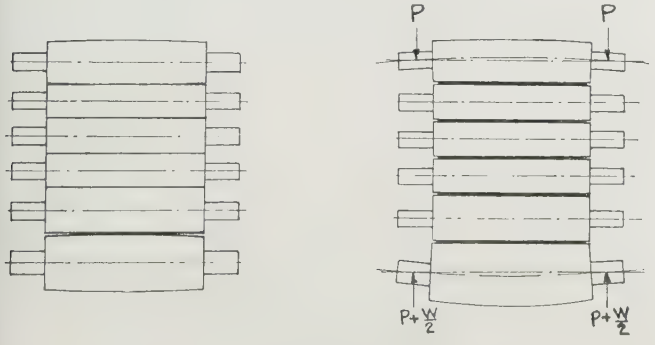

Fig. 4. Crowns in an unloaded and correctly loaded calender stack

CROWN VARIATION WITH LOADING CONDITIONS

Based on the foregoing, we now see that a properly crowned bottom roll, in any calender stack, in addition to insuring uniform pressure across the web, will provide a straight line, horizontal contact with the bottom surface of the next roll when supporting the weight of all the other rolls in the calender. Uniform pressure contact is most simply accomplished by crowning the bottom roll only, all the other rolls always remaining in the undeflected condition. When external pressure is applied on the top roll, it is necessary that it also be crowned, otherwise the deflecting ends would produce nonuniform pressure on the next roll, and so on successively on each nip throughout the calender. The amount of top roll crown is determined by the magnitude of the external load used. Figure 4 is a diagram of the crowns of a multiroll stack, in the unloaded and loaded conditions, where the crowns correspond correctly to the loading conditions. Other combinations of roll crowns can be used to obtain conformity, but no compensating advantages accrue against the complications involved, and in most cases, uniform pressure contact at the bottom roll would be lost.

It is apparent from what has been said that calenders can have correctly crowned rolls for one and only one set of loading conditions. It follows, therefore, that for any other operating conditions, the selected crowns represent a compromise between the amounts needed for perfect operation and the amounts found to be the least objectionable over the range of nips and pressures used. To approach uniform pressure across the width of the web, for small variations in nip pressures above or below those required for perfect operation, roll shape may be locally influenced at various points along the face of the roll. This is most usually accomplished by the use of cold or warm air, to either decrease or increase the roll diameter slightly, to improve the build-up on the paper winder.

To attempt to overcome the problems caused by changing deflections of the bottom calender rolls due

Table II. Various Crown Shapes Obtainable by Partial-Cosine-Crowning Mechanism

x/l	$y/y_{max.}$ $\alpha \to 0°$	$\alpha = 45°$	$\alpha = 71°$	$\alpha = 90°$
0	1.0000	1.0000	1.0000	1.0000
0.1	0.9600	0.9580	0.9546	0.9511
0.2	0.8400	0.8330	0.8215	0.8090
0.3	0.6400	0.6279	0.6085	0.5878
0.4	0.3600	0.3479	0.3292	0.3090
0.5	0.0000	0.0000	0.0000	0.0000

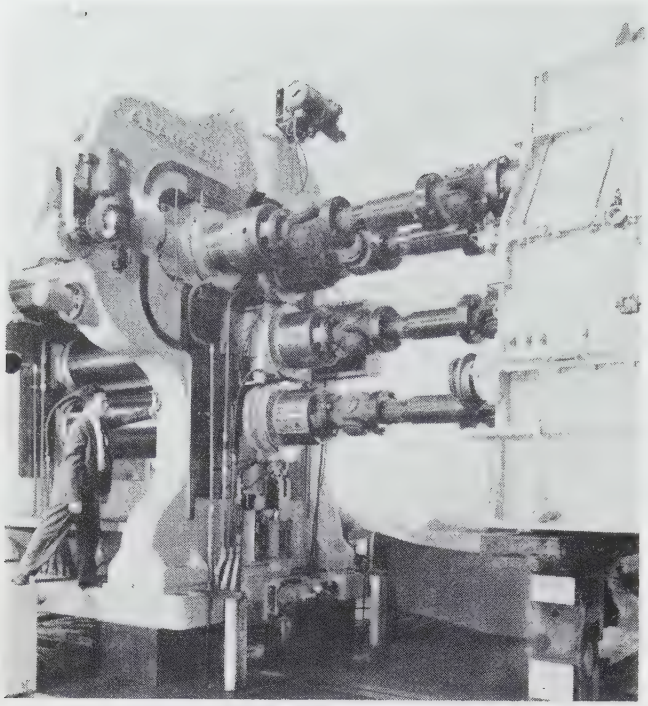

Fig. 5. L-type rubber calender, built by Adamson-United Co., incorporating principle of contour control by roll bending

to varying nips and pressures, antideflection rolls have been tried. The principle of these rolls has been known for many years, and they have been used for press rolls, printing rolls, embossing rolls, and even calenders processing heavy papers. The antideflection roll consists of a thick-walled, chilled-iron shell, ground straight, and pressed on a forged steel shaft, and supported at two suitably located positions on the shaft. The principle of operation is that the shaft bends under load, while the shell remains essentially straight. The problem has always been to obtain a satisfactory construction that would stand up in the field against the effects of heat, slippage, and corrosive action at the support points, wear of parts, etc.

Up to now, we have discussed crown control problems in paper machine calenders at some length. They are problems familiar to papermakers and engineers alike. Eighty-five years ago Carl Hofmann, whom we quoted, was aware of many of these problems for he wrote about "light-tightness" between rolls, and the need for large-diameter bottom rolls. Little has been accomplished in all this period to provide adequate and ready means of controlling paper calender crowns, to meet the many and varied operating conditions in this exacting area of papermaking.

INSTANTANEOUS CROWN CONTROL—A NEW DEVELOPMENT

We wish now to focus attention on a new development in the papermaking field which promises to obviate the problems in crown control that have plagued the industry since its beginnings. This development, while new to the field of papermaking, has been used successfully for several years now, in rubber and plastics calendering (*11*), and is based on the idea of roll bending by hydromechanical means. A rubber calender employing this system, built by the Adamson-United Co. (a subsidary of United Engineering and Foundry Co.) is shown in Fig. 5. where nip pressures up to 9000 lb. per in. are used.

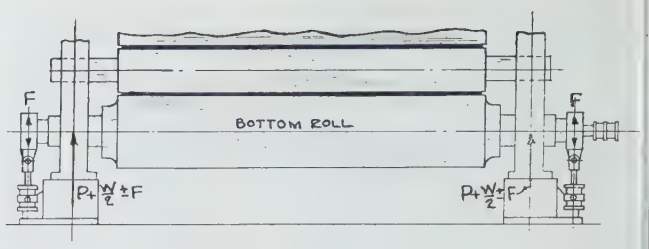

Fig. 6. Crown control roll bending mechanism, as applied to the king roll in a multiroll stack

Crown control by roll bending, as the name implies, is the simple process of inducing a deflection in the roll by applying equal and opposite bending moments at each end of the roll. Bending moments thus produced, acting opposite to those produced by the nip pressures on the calender roll, will have the same effect as an increase in the mechanical crown of the roll. Bending moments complementary to those created by the load on the calender roll will have the same effect as reducing the amount of groundon crown.

The roll-bending mechanism itself is relatively simple, consisting of auxiliary bearings mounted outboard of the main journal bearings on roll neck shaft extensions and loaded sufficiently by hydraulic pressure to produce the desired deflections in the roll. Hydraulic pressure can be applied through the cylinders to deflect the ends of the roll up or down, depending on the direction of the desired crown correction. In determining the amount of crown compensation that can be obtained for any given size of roll by the use of the roll-bending principle, proper recognition must be given to the magnitude of the bearing loads involved. The load that the roll-bending cylinder applies to increase the crown represents an additional load on the main bearings. Spherical roller bearings or rotationally mounted antifriction bearings are indicated for this type of calender, as they are readily lubricated and provide mountings that will prevent any binding tendency caused by roll bending. Accordingly, the housings for the roll-bending bearings are mounted separately from the main bearing housings.

APPLICATION TO PAPER CALENDERS

Figure 6 shows how the roll-bending mechanism is applied to the bottom roll of a multiroll stack. If a mechanical crown of one-half the maximum ever required is used on the roll, then by applying a roll bending force F, both up and down, a variation in crown

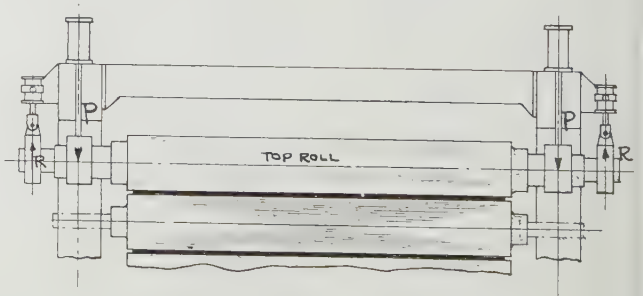

Fig. 7. Crown control for the top roll of paper calender stack—to accommodate varying external loads

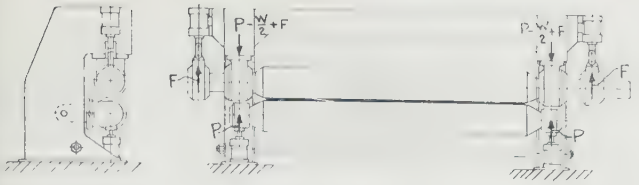

Fig. 8. Two roll tissue calender—with hydraulic contour control capable of maintaining light-tightness over a range of nip pressures of 10:1 and higher

from 0 to 100% is obtainable by applying ±50% to the median value. However, other constructions might well apply this force only downward, in which case, the same full range of crown control is obtained, but with twice the magnitude of roll-bending force. The first commercial application of the roll-bender principle of crown control to a paper calender is currently being made by the Black-Clawson Co. under an arrangement with United, who is furnishing the rolls. It is expected that a report on its operation will be made soon.

Figure 7 shows the application of the crown control principle to the top roll of a multiroll stack. In this case, since the external loading would be applied by hydraulic cylinders, the possibility exists of making the crown control entirely automatic (for a constant web width). By applying hydraulic pressure to both the main cylinders and the bending cylinders from the same pressure source, cylinder sizes and spacings can be selected whereby the roll-bender deflection equals the deflection due to nip pressure for any and all values of nip pressure—an operator luxury indeed.

In either of the cases described above full crown control may be had by bending the rolls always in only one direction, thus permitting the use of flat-ground cylindrical rolls for both the king roll and top roll as well as all the intermediates. In this type of construction and operation there may well be another operating virtue because under any and all conditions of operation there will exist no relative microslip of the paper with respect to the roll at the edges of the web relative to its center, which presently exists in mechanically crowned rolls due to the fact that they are larger in diameter at the center than at the ends.

Another type of paper calender employing this principle of crown control is shown in Fig. 8. Here is shown a single nip, two-roll calender such as is used for calendering tissue type paper where a large range of nip pressures is desirable to process a variety of products. The lower cylinders would control the nip pressure itself, and the cylinders acting on the top roll necks would bend the top roll downward to accurately and completely compensate for the bending of both rolls due to nip pressure. Here again, for a fixed tissue width the compensation can be made automatic. As an example of the compromise that operators must currently contend with, for a 15-in. diam × 125-in. wide calender, with nip pressure variations of 10 to 100 lb. per in. of width, the operator would undoubtedly grind his crowns for a median pressure of, say 55 lb. per in. The crowns for this condition would be 0.009 in. on each roll, correpsonding to a roll deflection of 0.0045 in. Now for 100 lb. per in. the rolls would deflect 0.008 in. each, if a uniform pressure distribution could be attained, which would mean that the rolls would be 0.007 in. further apart at the center than at the ends—an obviously untenable condition. What would take place would be a nonuniform distribution of pressure, being considerably greater at the edges of the web; and to improve the general situation, a yieldable surface would be used on at least one of the rolls, to further compensate to some extent. At best, a compromise operation condition is all that can be hoped for.

Thus, in this paper we have reviewed the matters of determination of total crowns and crown distribution along the roll body, in paper calenders, and their control. The present main method of altering crowns involves the lengthy process of roll removal from the stack and external grinding, to produce crowns that are suitable for essentially only one set of conditions. Slight variations in crown are attainable by cold or warm air jets that are both uncertain in their accuracy and relatively slow in their response. The use of the new hydromechanical roll bending principle will enable the operator to change crowns easily and rapidly, not only for product changes involving a different set of calendering conditions, but also to control better any given operation with changes in conditions such as roll temperature, paper moisture, roll wear, etc.

APPENDIX A

DEFLECTION CURVE OF CALENDER ROLLS

Figure 9 shows the basic loading diagram for a calender roll, and the nomenclature for determining the roll deflections at any point of the body with respect to the edges of the web, since this determines the distribution of crown. Here:

l = roll body
h = "overhang," see Fig. 1. and equation (1)
q = distributed loading
x = distance of any point in roll body from center
y = deflection at point x
M_0 = bending moment acting on the end of the roll body due to bearing load $ql/2$ multiplied by arm h

The general differential equation of bending for any beam is given by (*12*):

$$EI \frac{d^2y}{dx^2} = - M \qquad (4)$$

where

E = modulus of elasticity of beam material
I = moment of inertia of beam section $(\pi/64)d^4$
M = bending moment at any point x

Rearranging:

$$\frac{d^2y}{dx^2} = - \frac{M}{EI} \qquad \text{(bending)} \qquad (5)$$

The general differential equation of beam deflection due to shear, as given by (*12*):

$$\frac{dy}{dx} = k \frac{V}{GA} \qquad (6)$$

where

V = shear force at any section x
G = shear modulus $(^2/_5 E)$
A = cross-sectional area of beam section $((\pi/4)d^2)$
k = numerical shear factor, depending on the shape of the cross section ($^4/_3$ for circular sections)

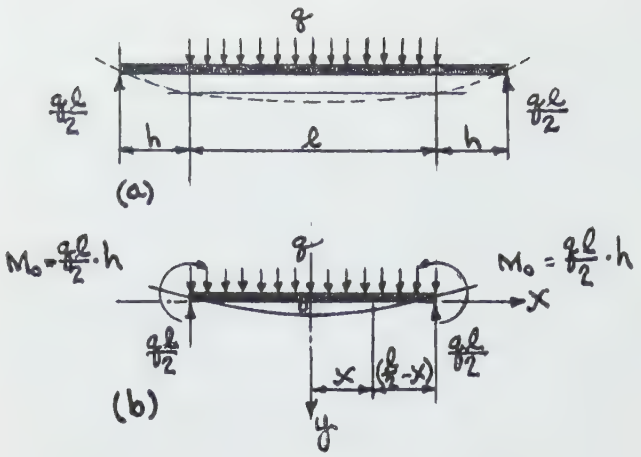

Fig. 9. Forces and moments for determining roll deflection curve

Differentiating equation (6), we get:

$$\frac{d^2y}{dx^2} = \frac{k}{GA}\frac{dV}{dx} \quad \text{(shear)} \tag{7}$$

The differential equation of beam deflection for both bending and shear, therefore, is obtained by combining equations (5) and (7) thus:

$$\frac{d^2y}{dx^2} = -\frac{M}{EI} + \frac{k}{GA}\frac{dV}{dx} \text{ (combined)} \tag{8}$$

Now, the expression of M at any point x is obtained by taking moments about x. From Fig. 9b we see that:

$$M = M_0 + \frac{ql}{2}\left(\frac{l}{2} - x\right) - q\frac{(l/2 - x)^2}{2}$$

$$= \frac{q}{2}\left[l\left(h + \frac{l}{4}\right) - x^2\right] \tag{9}$$

Also the shear force at point x is $V = q\,(l/2-x) - ql/2 = -qx$, whence $dV/dx = -q$. Substituting these values in equation (8), we get finally as our specific differential equation for the deflection of a roll body under combined shear and bending:

$$\frac{d^2y}{dx^2} = -q\left\{\frac{1}{2EI}\left[l\left(h + \frac{l}{4}\right) - x^2\right] + \frac{k}{GA}\right\} \tag{10}$$

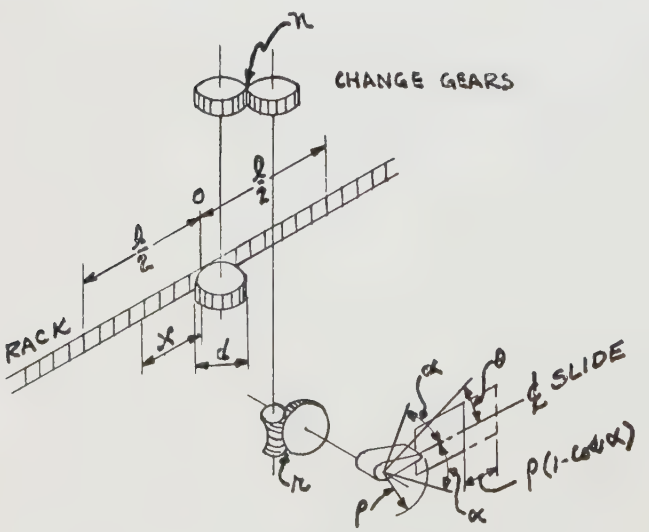

Fig. 10. Schematic mechanism for partial-cosine-curve crowning

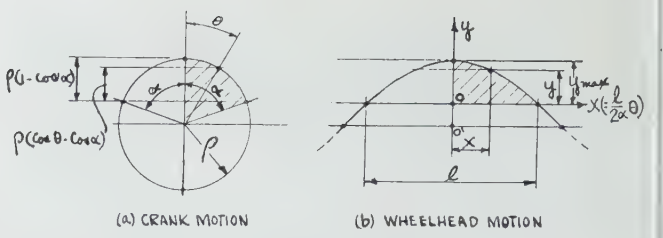

Fig. 11. Geometry of partial-cosine-curve crowning mechanism

Integrating twice, we get:

$$\frac{dy}{dx} = -q\left\{\frac{1}{2EI}\left[l\left(h + \frac{l}{4}\right)x - \frac{x^3}{3}\right] + \frac{k}{GA}x\right\} + C_1 \tag{11}$$

and

$$y = -q\left\{\frac{1}{2EI}\left[l\left(h + \frac{l}{4}\right)\frac{x^2}{2} - \frac{x^4}{12}\right] + \frac{kx^2}{2GA}\right\} + C_1x + C_2 \tag{12}$$

To evaluate the integration constants, we know that at $x = 0$, $dy/dx = 0$ and $y = y_{\max.}$; whence $C_1 = 0$ and $C_2 = y_{\max.}$. Thus equation (12) becomes:

$$y = -q\left\{\frac{1}{2EI}\left[l\left(h + \frac{l}{4}\right)\frac{x^2}{2} - \frac{x^4}{12}\right] + \frac{kx^2}{2GA}\right\} + y_{\max.} \tag{13}$$

Now, we know also that at $x = l/2$, y = 0. Substituting these values in equation (13) and rearranging, we get:

$$y_{\max.} = \frac{5ql^4}{384EI}\left[1 + \frac{24}{5}\left(\frac{h}{l}\right) + 2\left(\frac{d}{l}\right)^2\right] \tag{14}$$

And substituting for $y_{\max.}$ in equation (13) its value from equation (14), and rearranging, we obtain:

$$y = \frac{5ql^4}{384EI}\left\{\left[1 + \frac{24}{5}\left(\frac{h}{l}\right) + 2\left(\frac{d}{l}\right)^2\right] - 8\left[\frac{3}{5} + \frac{12}{5}\left(\frac{h}{l}\right) + \left(\frac{d}{l}\right)^2\right]\left(\frac{x}{l}\right)^2 + \frac{16}{5}\left(\frac{x}{l}\right)^4\right\} \tag{15}$$

APPENDIX B

PARTIAL-COSINE-CURVE CROWNING MECHANISM FOR ROLL GRINDERS

Figure 10 shows schematically the essential elements of a modern roll grinder crowning mechanism capable of producing not only a large range of total crowns, but also a large choice of crown shapes to fit a large range of roll body lengths, l. As the crowning mechanism transverses along the roll length $\pm(l/2)$, from the centerline of the roll, O, it is immediately seen that the limiting crank angle $\pm\alpha$, is given by:

$$\alpha = 180/\pi dr \cdot l/\eta \tag{16}$$

The general crank angle, θ, is given by

$$\theta = 360/\pi dr \cdot x/\eta$$

d = diameter of rack gear
r = ratio of worm gear
η = ratio of change gears
ρ = radius of crank (Fig. 10)

Figure 11a, shows the various positions of the crowning mechanism crank and Fig. 11b, the motion of the wheelhead carriage y is plotted against the carriage position x. The shape of this latter curve, with respect to point O', is a true cosine curve. However, if we wish to vary the shape of this crowning curve by

making it correspond to various partial-cosine-curves, represented by a different origin, O, then by comparing the geometries of Figs. 11a and 11b we obtain:

$$\frac{y}{y_{max.}} = \frac{\rho(\cos\theta - \cos\alpha)}{\rho(1 - \cos\alpha)}$$

$$y = y_{max.}\left[\frac{\cos\theta - \cos\alpha}{1 - \cos\alpha}\right] \qquad (17)$$

By noting also that $x = (l/2\alpha)\theta$, we may write:

$$y = y_{max.}\left[\frac{\cos(2\alpha/l)x - \cos\alpha}{1 - \cos\alpha}\right] \qquad (18)$$

Both equations (17) and (18) are the equations of partial-consine-curve crown shapes. For $\alpha = 90°$ $(= \pi/2)$, we get $y = y_{max.} \cos\theta = y_{max.} \cos(\pi/l)\, x$ — equations for true cosine curves.

In order to obtain any desired crown shape, determined essentially by selecting a maximum crank angle α, we see also that we can retain this selected angle α for any and all roll body lengths l by properly altering the change gear ratio η—and get any crown, 2 $y_{max.}$, by selecting the properly associated value of ρ.

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Free Hydroxide as a Control in Kraft Cooking

E. T. O'BRIEN, H. D. BAUMAN, and R. F. CASHEN

A simple, rapid potentiometric method for determining hydroxide and sulfide in black liquor is described. Since the time required for this determination is less than 15 min., it has been highly useful as a control measure on experimental pilot cooks using a 1.5 cu ft. digester. The method has been applied to experimental mill cooks. A series of cooks on hardwoods shows that continuing a cook beyond the point of exhaustion of free hydroxide lowers the yield without appreciably lowering the permanganate number. Yield losses as high as 9% were observed with less than one unit drop in permanganate number. Comparative data on unbleached pulps are given.

As part of a research program investigating the kraft pulping of different species of wood, it became important to have a method for following the extent of the pulping reactions in a pilot digester and determining the time for stopping a cook. While good results in duplicating yield and permanganate numbers were obtained using the H factor concept (*1*) under a given set of conditions, it was still necessary to do wasteful hit-or-miss cooks when changing to unfamiliar cooking conditions.

The work of Borlew and Pascoe (*2*) showed that the bulk of sodium sulfide consumption occurs in the early stages of a cook and then almost ceases. Only a small portion of the sodium sulfide is consumed thereafter. The bulk of sodium hydroxide consumption also occurs in the early stages of a cook but continues on until all the sodium hydroxide is consumed. This suggested the idea that for any set of conditions the point beyond which a cook should not be continued is the exhaustion of free hydroxide in the cooking liquor, and that a knowledge of the concentration of free hydroxide in the liquor could be used as an accurate indication of the degree of pulping. There have been indications that cooking beyond the exhaustion of free hydroxide might be distinctly detrimental to both pulp yield and pulp quality. A "dangerous crest of pulping" was described by Surewicz (*3*), cooking beyond which results in downgrading pulp quality. This crest occurs more frequently when most of the alkali has been consumed.

For the concentration of free hydroxide in the cooking liquor to be of value in controlling the cooking time, an analytical method for free hydroxide which would give accurate results in a matter of minutes is essential. Consideration of the many methods proposed for determining sodium sulfide and sodium hydroxide in black liquor indicated that the method of Borlew and Pascoe (*2*, *4*) was best suited for this purpose. In this method, sodium sulfide is measured by a potentiometric argentimetric titration.

ANALYTICAL METHOD

A simple, rapid adaption of the Borlew-Pascoe method was evolved which can be carried out in less than 15 min. with satisfactory accuracy and excellent precision. Thus, knowledge of the free hydroxide content of the cooking liquor in the digester follows very closely after taking a sample. As carried out, this control method consists of the following steps:

(a) A 25-ml. sample of black liquor is pipetted into a glass-stoppered, 250-ml. volumetric flask containing about 100 ml. of water and 50 ml. of 10% $BaCl_2$ solu-

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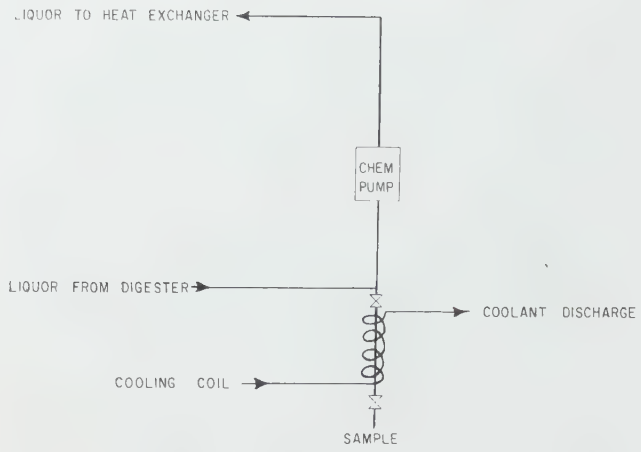

Fig. 1. Black liquor sampler

tion, filled to the mark with distilled water and mixed well. A portion of the contents is at once transferred to two 15-ml. centrifuge tubes and centrifuged for about 5 min.

(b) While the centrifuge is running, sodium sulfide is determined by a potentiometric titration on a separate sample of black liquor. Ten milliliters of the black liquor are pipetted into a 250-ml. beaker containing about 125 ml. of a solution 1 *N* in NaOH and 0.05 *N* in NH_4OH. Using a magnetic stirrer, the solution is titrated with standard silver nitrate solution (1

Table I. Hydroxide and Sulfide Content of Black Liquor in Duplicate Cooks

Cooking time, min.	*Cook no. 1*		*Cook no. 2*	
	Na_2S, g./l.	*NaOH, g./l.*	*Na_2S, g./l.*	*NaOH, g./l.*
0	10.2	32.2	10.2	32.2
90	7.6	4.1	7.6	4.1
120	7.4	1.8	7.3	1.9
150	6.2	0	6.3	0
195	6.0	−1.8	6.2	−1.7

ml. of $AgNO_3$ equivalent to 0.020 g. Na_2S). The equivalence point is determined using a Fisher titrimeter, Model 9-311A, in which the sharp potential difference at the equivalence point causes the opening of an indicator eye (tube 6E5). The indicator electrode is a silver–silver sulfide electrode and the reference electrode is a Beckman, high-pH glass electrode. At the equivalence point, one drop of silver nitrate solution

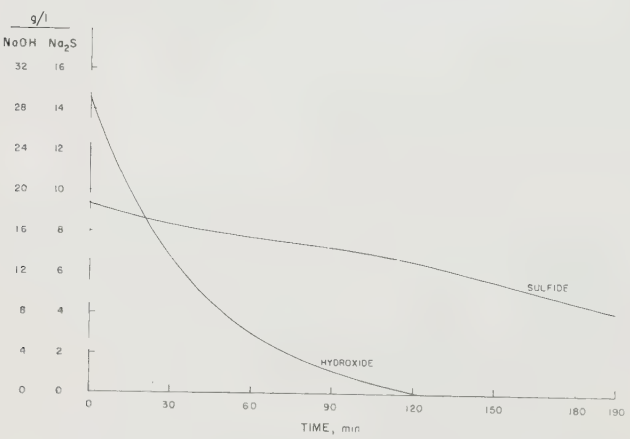

Fig. 2. Residual sulfide and hydroxide vs. time; active alkali, 15.5%

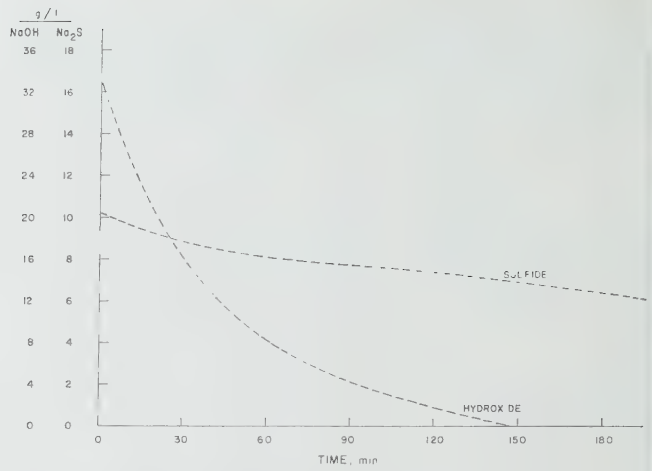

Fig. 3. Residual sulfide and hydroxide vs. time; active alkali, 17%

causes a sharp change in the indicator eye, from closed to wide open.

(c) The centrifuge is stopped and from each tube 5 ml. of clear centrifugate is pipetted into a 50-ml. beaker containing about 25 ml. of water. Using a Beckman Zeromatic pH meter, fitted with a high-pH electrode, this solution is titrated with 0.01 *N* HCl to a pH of 10.

To calculate the sodium sulfide content of the black liquor, twice the volume (ml.) of silver nitrate solution used in the potentiometric titration gives the weight (g.) of sodium sulfide per liter. In the titration with 0.01 *N* HCl to pH 10, since the sodium sulfide content is known, the hydrochloric acid consumed by the sulfide can be calculated. In this titration the reaction involving sulfide is $S^= + H^+ \rightarrow HS^-$, the milliequivalent weight of sodium sulfide is 0.078 g. The difference between the total hydrochloric acid used in the titration and that required to react with the sulfide is the acid consumed by the free hydroxide in the black liquor.

In the potentiometric titration for sulfide, the titrimeter is calibrated for the indicator eye to open at −400 mv. A titration curve, of potential (mv.) against volume (ml.) of titrant, obtained by titrating sodium sulfide solution with silver nitrate solution, showed a sharp inflection point at −400 mv. Titration curves using black liquor show two inflection points; one at

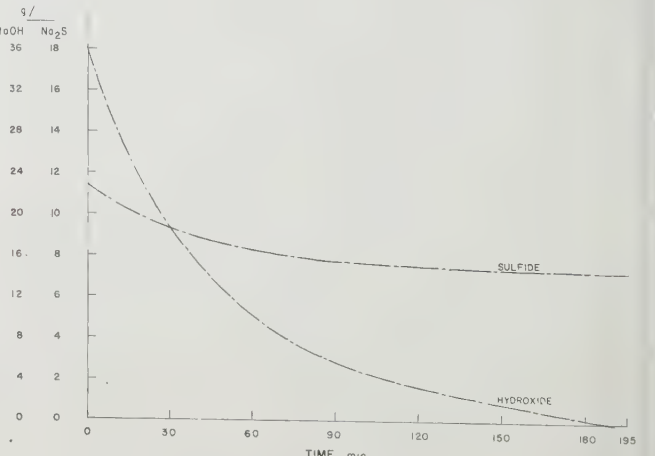

Fig. 4. Residual sulfide and hydroxide vs. time; active alkali, 19%

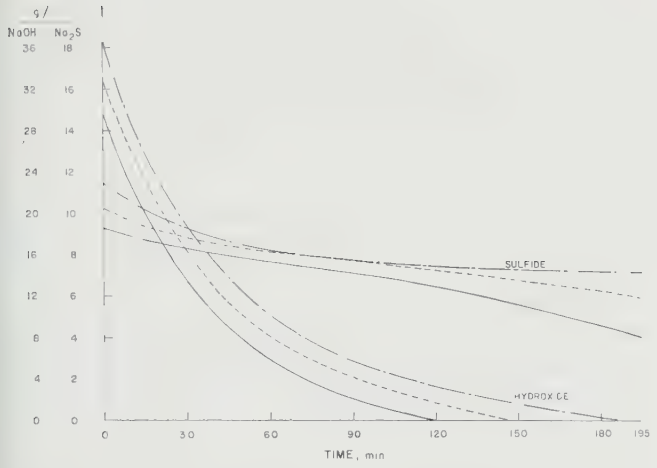

Fig. 5. Residual sulfide and hydroxide vs. time

−400 mv. and another centered about 0 mv. Borlew and Pascoe (*4*) gave −420 mv. for the inflection point occurring at the equivalence point in the titration of sulfide. The inflection point occurring at 0 mv. has been shown (*5, 6*) to give the end point for the titration of mercaptans with silver nitrate. Samples of black

Table II. Time Required to Exhaust Free Hydroxide

Active alkali, %	*Time, min.*
15.5	120
17.0	145
19.0	190

liquor taken at the end of experimental cooks are titrated first to the inflection point at −400 mv. The calibration of the instrument is changed to 0 mv. and the titration continued. A single titration thus gives data on both the sulfide content and the mercaptan content of the black liquor.

Collins has reported (*7*) a careful comparison of methods for determination of sulfide in oxidized sulfate black liquor. He concluded that the Borlew-Pascoe method is the simplest and most rapid way of carrying out the analysis. He found no great error due to oxidation of the sample during the titration, if the analysis is carried out rapidly. Collins also reported (*7*) that storing a black liquor sample in a completely filled, clear

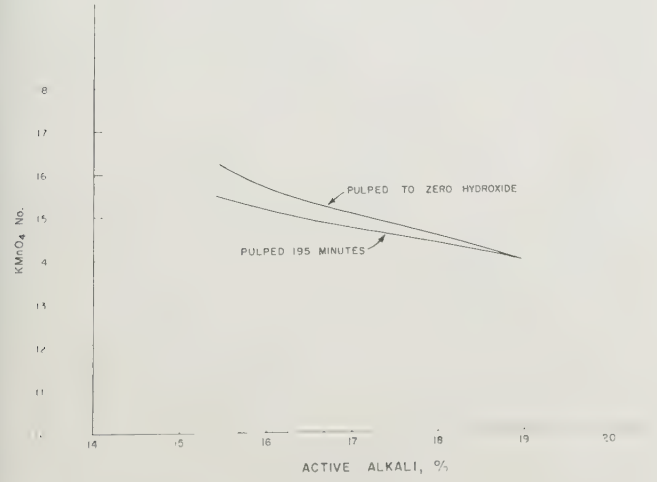

Fig. 6. Permanganate number vs. active alkali

glass container with a tight stopper for one month results in no lowering of the sulfide content.

In the present work samples of black liquor stored in completely filled, glass-stoppered clear bottles showed no drop in sulfide content when stored at room temperature for two weeks. Samples in open containers or partly filled bottles showed rapid drop in sulfide content. In studying pilot cooks, all analyses were made immediately after sampling.

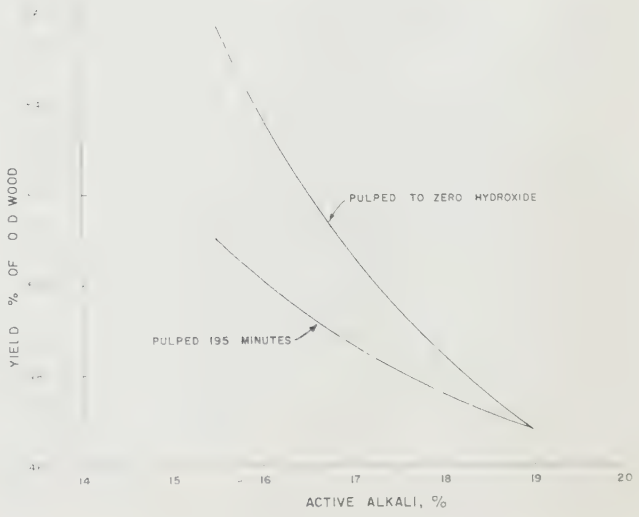

Fig. 7. Yield vs. active alkali

EXPERIMENTAL COOKS

A 1.5-cu. ft. pilot digester was fitted with a simple device for taking samples of black liquor during a cook. Figure 1 is a diagram of the black liquor sampler. The volume of sample taken by this device is about 50 ml. The volume was purposely kept small

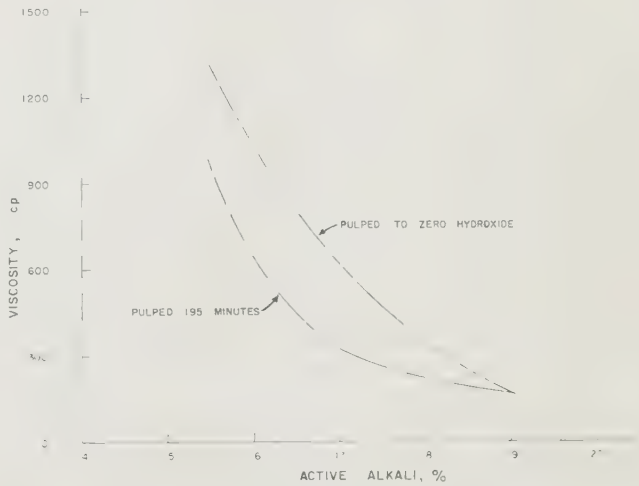

Fig. 8. Viscosity vs. active alkali

so that a number of samples could be taken during a single cook without seriously altering the liquor-to-wood ratio or the per cent alkali. No difference in permanganate number of the pulp was observed when three samples were taken during a cook, compared to a duplicate cook with no samples taken. However,

taking a sample every 15 min. during a 3-hr. cook raised the permanganate number as much as lowering the initial active alkali by 1%.

To test the reproducibility of results using this analytical method, and to study the consistency of behavior of the pilot digester, a number of pairs of duplicate cooks were made taking samples of liquor at the same time intervals, using several wood species and a variety of initial active alkali concentrations. Results shown in Table I are typical. These were duplicate cooks made on white oak at 17.0% active alkali, all other conditions were as given below under Pulping Conditions. Sodium hydroxide and sodium sulfide are given as Na_2O.

The negative values for the residual hydroxide at 195 min. result from the fact that when there is no free hydroxide, the hydrochloric acid used in the titration to pH 10 is reacting to some extent with HS^-.

It was decided to apply the analysis for residual free hydroxide to experimental cooking of hardwoods. Preliminary tests at selected active alkali levels were made to follow the consumption of both hydroxide and sulfide during the cooking of green white oak. The concentrations of sodium sulfide and sodium hydroxide, in grams per liter as Na_2O, were plotted against cooking time. Figure 2 shows the chemical consumption for a 15.5% active alkali charge while Figs. 3 and 4 show the corresponding consumptions for active alkali charges of 17.0 and 19.0%.

As anticipated from the work of Borlew and Pascoe (*2*), the sodium sulfide consumption leveled off at about the time maximum temperature was reached. However, as shown in Figs. 2 and 3, it was interesting to note that when the free hydroxide reached zero the consumption of sodium sulfide resumed.

Figure 5, which combines the three pairs of curves, shows that regardless of the initial active alkali concentration equal amounts of sodium hydroxide were used for a given time interval until the point was reached where the free hydroxide was exhausted.

Pulping Conditions

Pilot kraft pulps were prepared from white oak with liquor containing 15.5, 17.0, and 19.0% active alkali (as Na_2O) and 24% sulfidity on a moisture-free wood basis. The liquor-to-wood ratio was 4:1 with fresh water being used for the necessary dilution. Only chips passing a 1-in. screen and retained on a $^1/_2$-in. screen were used. The cooking cycle took 1.5 hr. from 70 to 173°C. (110 p.s.i.g. at maximum). Time at maximum temperature was 1.75 hr. for the preliminary cooks and was then varied for subsequent cooks, depending upon the exhaustion of free hydroxide.

All the pulps discussed in this paper were cooked in a perforated stainless steel basket in a 1.5-cu. ft. laboratory digester. The cooked chips were washed in the basket, fiberized, rewashed, and screened on a 12-cut flat screen. The screened pulps were centrifuged to 25–30% consistency and sealed in polyethylene bags for storage at 38°F.

Permanganate numbers were determined according to TAPPI Standard T 214 m-50 (25 ml.), and 1% cupriethylenediamine viscosities were determined according to TAPPI Standard T 230 sm-50 (Falling Ball Method). Pulp yields were determined by weighing the total amount of centrifuged pulp, quartering this pulp, and obtaining several consistency samples; the consistency samples and the screen rejects were then dried to constant weight at 105°C.; and the yield has calculated as moisture-free pulp based on the moisture-free wood.

DISCUSSION OF RESULTS

As previously mentioned, continuing the cooking cycle beyond the point of free hydroxide exhaustion could be detrimental to both pulp yield and pulp quality. A series of additional cooks was made at the 15.5 and 17.0% active alkali levels, using the free hydroxide test as a means of controlling the cooking cycle. Times required to exhaust free hydroxide are shown in Table II.

Figure 6 shows that when the cook was stopped at the point of hydroxide exhaustion a slightly higher permanganate number existed when compared to the 195-min. cooking cycle. However, this difference was less than one permanganate-number unit and therefore, the data must be considered to indicate only a possible trend.

Figure 7 shows the relationship between unscreened pulp yield and active alkali for both cooking cycles. These curves show that stopping the cook at the point of free hydroxide exhaustion, a significant increase in pulp yield will result: 4.3% more pulp at the 17.0% active alkali level and 9.0% more pulp at the 15.5% active alkali level, without a corresponding increase in permanganate number.

Figure 8 shows the relationship between pulp viscosity and active alkali. In this plot it can be clearly seen that by continuing the cooking cycle past the point of hydroxide exhaustion, pulp degradation is taking place at a very rapid rate. Similar pilot cooks on other hardwood species gave very similar results. Cooks on pine species gave a somewhat different behavior which is currently being studied.

CONCLUSIONS

Continuing a kraft cook beyond the point of free hydroxide exhaustion results in serious loss of yield and lowering of pulp quality, as measured by viscosity, with little or no lowering of permanganate number.

Determination of free hydroxide is a valuable tool in experimental cooking.

The analytical method described here is sufficiently rapid and simple to be used as a routine control test in mill cooking. Work is being done to determine its applications for this use.

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A Search for New Fiber Crops

Part III. Laboratory-Scale Pulping Studies

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To evaluate nonwoody fibrous materials as pulp sources, the sulfate (kraft) pulping process, at a 15% level of chemical and combined with a simple refining technique, were applied to 1-lb. samples of 61 plant materials selected on the basis of analytical data. Based on pulp yields, chemical consumption, initial and refined freeness, permanganate values and strength properties, supplemented by statistical analysis of the data, mallow plants were found to have favorable characteristics for use in pulp and papermaking. Under the conditions used, pulp yields ranged up to 57%, burst factors to 50, tear factors to 64, and Schopper folds to 1000. Certain legumes and grasses also possessed characteristics favoring their consideration for pulp and papermaking. Alkali solubility of raw materials and their ease of pulping, judged by permanganate numbers and extent of delignification, were significantly greater for grasses than for dicotyledons. Bursting and folding strengths for papers from dicotyledons were significantly better than for those from grasses. No significant differences in tear strength were observed between the two groups of plant materials. Relationships between alpha-cellulose content and pulp properties were highly significant for both grasses and dicotyledons. Relationships between fiber dimensions and pulp properties were highly significant for dicotyledons, but not for grasses.

In earlier reports from this laboratory (*1–3*) factors have been cited that indicate the desirability of finding suitable, new, nonwoody fibrous crops to serve as pulp and papermaking raw materials. Adequate criteria for critical comparisons and evaluations of large numbers of plant species were not evident, so an analytical scheme and point evaluation system for preliminary screening were devised. This procedure made possible a primary division of plant materials into groups having relatively greater or less promise as pulp sources.

More rigorous appraisal of samples by a small-scale pulping procedure (including handsheet evaluation) was desired (a) to permit further selection and narrowing in the choice of preferred raw materials, and (b) to serve as a guide to the validity of the analytical screening. Data which have since been acquired on the laboratory pulping of 61 samples provide the basis of the present report.

Materials selected for pulping are primarily those which appeared to be most promising on the basis of prior studies. However, a few lower quality samples were included to provide a wider range of properties; several standard fibrous raw materials were given identical treatment for comparative purposes. The sulfate process was chosen for the experimental pulping because of its general applicability to many different types of raw materials and its tendency to give strong pulps.

At the outset certain difficulties inherent in these evaluations were recognized. One operating procedure may be inadequate for deciding whether the pulp yield and pulp properties are characteristic of a raw material or merely indicate varying response to the chosen experimental conditions. This limitation is especially true if beater evaluations to assure maximum strength development are not performed. Yet compromise is essential if numerous samples are to be evaluated in a reasonable time. Consequently, we made the arbitrary selection of a pulping and refining method and used it without modification on all raw materials. Critical examination of the data, with the aid of statistical analyses, indicates that useful information has been acquired in comparative, evaluation of the raw materials.

EXPERIMENTAL

Materials

The plant materials (Table I) used were obtained as before (*1*) and included 29 monocotyledons (all grasses) and 31 dicotyledons. Several samples were examined in a few promising genera such as *Hibiscus*, *Crotalaria*, and *Sorghum*. For reference and comparison two wood samples, wheat straw, esparto (*Stipa tenacissima*), and soybean stalks (a relatively poor material) were pulped.

Sample Preparation

Samples were chipped (bamboo), chopped, or cut into about 1-in. lengths using handtools, a paper cutter, or pilot-plant equipment, whichever was the most appropriate. All monocotyledons included stems, leaf sheaths, and leaves. For the dicotyledons the large leaves and seed (fruit) were first removed, if present, and the remainder cut for pulping. However, most dicotyledons were received with all or a part of the leaves removed.

The moisture content of each sample was determined, and sufficient air-dry material weighed to give 460 g. of ovendry matter for pulping.

Pulping Procedure

A small, black iron, rotary digester equipped with a steam jacket was used for pulping. It had a capacity of from 0.5 to 1.5 kg. of dry matter, depending upon the density of the sample. A 15% kraft cook was used, containing a ratio of one part sodium sulfide to two parts sodium hydroxide (active alkali as Na_2O, 11.7%; sulfidity, 33.9%).

The digester was preheated; the sample, chemical, and water necessary to obtain a 7:1 ratio of liquid-to-

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Table 1. Data on Pulping and Pulp Properties: 15% Kraft (Active Alkali as Na_2O, 11.7%; Sulfidity, 33.9%)

Sample no.	Material	Common name	Where grown	Type of plant[a]	Chemical consumed in pulping: Na_2S, %	$NaOH$, %	Total consumed, %	Pulp yield: Screened, %	Pulp yield: Screenings, %	Permanganate number	Pulp properties: Refining: Freeness: Initial	Freeness: After refining	Freeness: Decrease, %	Time refined in Morden, sec.	Strength of handsheets: Burst[c] factor	Tear[d] factor	Fold, Schopper double folds	Sample no.
					Reference Samples													
1	*Picea* sp.	Spruce	..	..	87	92	90	57.8	2.8	74.5	905	695	23	375	70	77	609	1
2	*Acer* sp.	Maple	..	D	89	97	94	56.4	0.3	39.3	850	645	24	425	61	65	699	2
3	*Stipa tenacissima*	Esparto	Spain	M	66	88	80	53.6	0.1	5.2	890	665	25	420	56	136	902	3
4	*Glycine max.*	Soybean	Illinois	D	..	..	..	52.9	0.4	59.1	745	615	18	90	15	70	4	4
5	*Triticum aestivum* (kawvale)	Wheat	Illinois	M	84	92	89	47.3	0.1	14.6	785	575	27	120	44	60	175	5
					Experimental Samples													
6	*Crotalaria juncea* (Brazilian)	Sunn hemp	Illinois	D	..	..	..	60.2	0.4	55 0	795	655	18	345	33	72	266	6
7	*Sesbania sonorae*	Sesban	Arizona	D	..	..	..	58.8	0.6	60.3	820	625	24	285	37	49	239	7
8	*Hibiscus cannabinus* variety 52-41	Kenaf	Florida	D	..	..	..	57.3	3.3	52.0	780	610	22	105	38	64	348	8
9	*Asclepias incarnata*	Swamp milkweed	Nebraska	D	62	99	87	57.2	0.9	62.1	675	540	20	210	22	78	93	9
10	*Abutilon theophrasti*	Velvet weed	Illinois	D	89	100	91	57.1	0.2	60.8	760	595	22	105	42	56	349	10
11	*Crotalaria juncea* (smooth stem)	Sunn hemp	Texas	D	89	100	88	56.3	0.0	57.4	800	640	20	165	45	51	501	11
12	*Crotalaria juncea*	Sunn hemp	Illinois	D	..	..	..	55.9	0.4	54.8	830	625	25	540	37	81	277	12
13	*Sorghum vulgare* PQX65584	Sorghum	Maryland	M	..	..	..	55.7	0.2	50.9	810	595	27	345	36	55	178	13
14	*Ambrosia trifida*	Giant ragweed	Nebraska	D	77	100	92	55.5	0.2	67 9	760	590	22	105	24	40	34	14
15	*Crotalaria juncea* (ridged stem)	Sunn hemp	Texas	D	69	100	90	55.5	0.1	55.6	800	610	24	540	46	62	643	15
16	*Hibiscus esculentus* (Louisiana market)	Okra	Louisiana	D	91	100	97	55.2	0.8	61.0	795	610	23	120	38	42	617	16
17	*Hibiscus esculentus* (Louisiana green velvet)	Okra	Louisiana[b]	D	89	106	96	54.8	0.1	46.4	790	625	21	105	50	46	1,008	17
18	*Hibiscus cannabinus* variety 52-41	Kenaf	Corn Belt	D	81	100	92	54 6	0.6	53.8	725	570	21	90	44	59	417	18
19	*Desmanthus* sp.	Bundle flower	Kansas	D	84	100	94	54.3	1.0	63.3	725	575	21	225	27	49	64	19
20	*Lupinus formosus*	Lunaria lupine	California	D	92	100	97	54.2	0.3	61.1	795	640	20	240	20	40	21	20
21	*Helianthus grosseserratus*	Sawtooth sunflower	Kansas	D	82	100	94	53 5	0.9	60.9	730	595	19	165	26	46	32	21
22	*Hibiscus sabdariffa*	Roselle	California	D	86	98	94	53.3	0.4	64 3	770	585	24	120	48	59	537	22
23	*Crotalaria intermedia*	Kotschy	Georgia	D	68	98	88	53.1	0.5	55.9	785	630	20	300	30	64	140	23
24	*Iva xanthifolia*	Rag sumpweed	Nebraska	D	95	100	98	52.6	0.1	65.9	750	585	22	105	24	43	27	24
25	*Dalea alopecuroides*	Foxtail dalea	Iowa	D	92	100	97	52.5	0.2	62.3	790	635	20	150	32	65	102	25
26	*Ricinus communis*	Castor	Nebraska	D	91	100	97	52.1	2.6	67.4	725	560	23	210	37	54	455	26
27	*Dalea enneandra*		Kansas	D	71	97	90	50.8	0.4	56.6	855	655	23	450	28	54	41	27
28	*Sorghum alum*		Illinois	M	66	97	87	50.7	0.0	21.7	825	610	26	165	42	52	217	28
29	*Gynerium sagittatum*	Uva grass	Honduras	M	68	95	86	50.3	0.2	35.9	875	685	22	360	43	92	289	29
30	*Sorghum vulgare* PI177549	Sorghum	Texas	M	..	..	..	49.8	0.1	21.5	740	515	30	120	37	34	144	30
31	*Phyllostachys bambusoides*	Bamboo	Georgia	M	..	..	..	49.7	0.5	48.5	900	700	22	555	46	81	284	31
32	*Pennisetum spicatum*	Pearl millet	Georgia	M	87	100	96	49.3	0.1	39.1	805	625	22	175	40	44	194	32
33	*Althaea rosea*	Hollyhock	Maryland	D	86	99	94	49.0	2.1	66 0	735	535	27	120	30	46	146	33
34	*Sorghum vulgare* (kaoliang PI71310)	Sorghum	Texas	M	85	99	95	48.9	0.4	29.4	810	640	21	90	28	41	36	34
35	*Pennisetum typhoides*		Illinois	M	87	100	95	48.8	0.0	24.9	775	595	23	90	42	40	173	35
36	*Sorghum vulgare* PI62610	Sorghum	Texas	M	91	98	95	48.8	0.1	23.8	790	620	22	120	38	36	153	36
37	*Helianthus maximiliani*	Maximilian sunflower	Kansas	D	..	..	..	48.7	1.6	67.8	750	575	23	130	20	39	8	37
38	*Arundo donax*	Giant reed	Maryland	M	82	95	92	48.6	0 3	44.9	755	585	24	180	32	44	82	38
39	*Sorghum vulgare* (kaoliang PI88000)	Sorghum	Texas	M	88	98	95	48.6	0.0	21.9	785	585	26	130	39	36	174	39
40	*Asclepias incarnata*	Swamp milkweed	Maryland	D	81	97	92	48.3	2.7	63.3	700	555	21	120	16	46	11	40
41	*Hibiscus cannabinus* (variety 52–41)	Kenaf	California	D	89	100	96	48.3	0.3	51.3	730	575	21	105	38	54	465	41
42	*Sorghum vulgare* (kaoliang thick rind CI792)	Sorghum	Texas	M	89	99	96	48.2	0.4	28.7	805	600	26	100	35	39	88	42
43	*Helianthus scaberrimus*	Blackhead sunflower	Nebraska	D	96	100	98	47.9	0.0	63.0	765	605	21	120	26	46	31	43
44	*Andropogon gerardi*	Blue stem	Kansas	M	60	96	84	47.6	0.0	15.1	790	555	30	105	38	43	120	44
45	*Miscanthus sinensis*	Chinese silvergrass	Maryland	M	63	96	85	47.6	0.0	22.7	795	595	25	115	36	42	113	45
46	*Sorghum vulgare* (kaoliang PI71309)	Sorghum	Texas	M	84	99	94	47.4	0.0	19.5	805	625	22	120	36	44	148	46
47	*Sorghum halepense*	Johnson grass	Maryland	M	62	98	86	47.1	0.2	19.3	765	600	22	165	32	55	97	47
48	*Asclepias syriaca*	Common milkweed	Nebraska	D	72	100	91	46.9	5.3	51.5	570	465	18	90	18	62	19	48
49	*Apocynum cannabinum*	Hemp dogbane	Maryland	D	81	99	92	45 6	3.1	55.1	595	480	19	135	21	48	19	49
50	*Andropogon intermedius*	Australian bluestem	Texas	M	91	98	96	45.5	0.2	28.9	810	630	22	180	26	34	17	50
51	*Sorghum halepense*	Johnson grass	Texas	M	86	98	94	45.5	0.2	22.5	790	600	24	125	35	34	96	51
52	*Andropogon hallii*	Sand bluestem	Oklahoma	M	86	98	94	45.3	0.0	25.7	795	580	27	145	36	42	88	52
53	*Lygeum spartum*	Albardine grass	Spain	M	62	96	85	45.2	0.0	13 9	865	615	29	355	40	114	218	53
54	*Sorghastrum nutans*	Yellow Indian grass	Nebraska	M	84	100	94	43.8	0.0	16.7	835	675	19	175	31	41	16	54
55	*Cenchrus* sp.	Sandbur	Arizona	M	88	98	95	42.7	0.1	38.2	810	655	19	90	30	38	30	55
56	*Sorghum vulgare* (Sudanense 34641FC)	Sudan grass	Texas	M	88	99	96	42.1	0.1	25.4	795	590	26	105	33	34	78	56
57	*Tripsacum dactyloides*	Eastern gama grass	Maryland	M	75	98	90	40.9	0.1	27.8	770	620	20	235	40	40	86	57
58	*Hibiscus esculentus*	Okra	Nebraska	D	76	100	92	40.6	0.1	50.5	755	580	23	135	40	46	442	58
59	*Andropogon intermedius*	Australian bluestem	Kansas	M	70	96	88	40.4	0.2	15.7	825	615	26	105	32	46	37	59
60	*Arundinaria tecta*	Switch cane	Maryland	M	73	98	89	38.9	0.1	48.0	795	625	21	255	17	38	4	60
61	*Stipa viridula*	Green needle grass	North Dakota	M	71	93	86	38.8	0.4	16.6	775	595	23	75	50	46	222	61

[a] M = monocotyledon, D = dicotyledon
[b] Average value of samples from Illinois, Indiana, Missouri, and Nebraska.
[c] Burst in g./cm.²/g.s.m.
[d] Tear in g./g.s.m.

dry solids were added; and the digester was closed and rotated. The temperature of the digester was raised as rapidly as possible to 170°C. (5–15 min.), and the sample cooked at this temperature for 2 hr. At the end of the cooking cycle, the rotation was stopped, the steam released from the jacket, and the pressure in the digester reduced to atmospheric as rapidly as possible, using a water-cooled condenser to collect the vapors. Blowdown required from 5 to 15 min. The pulp was removed from the digester and washed free of chemical. A sample of the cook liquor was analyzed for residual sodium sulfide and sodium hydroxide.

The washed pulp was given a preliminary refining by passing through a single-disk mill equipped with grid-type plates set at 0.002-in. clearance. The pulp was screened in a Valley screen through plates with 0.008-in. slots. If considerable pulp remained on the slotted plates, it was run through the disk mill again at the same setting and rescreened. Yields of screened pulps and of screenings were determined. Some materials were so well pulped that they defibered on washing, and these pulps were screened without any preliminary refining. The permanganate number of the screened pulp was determined.

The screened pulps were further refined in a laboratory-size Morden stockmaker. A 95-g. sample (ovendry solids) of the pulp was made up at 2% consistency, placed in the refiner, and circulated with the rotor up or free for 1 min. Initial freeness was determined. The pulp was then refined with the rotor down until the freeness dropped approximately 20 to 30%. The pulp was removed and handsheets were prepared for determination of burst, tear, and fold by standard TAPPI methods.

Results reported in the next section represent an average of two experiments, except for a few instances in which an insufficient sample was available. Duplicate runs checked closely.

RESULTS

Experimental data, listed in order of decreasing yields, are summarized in Table I. Very little material remained on the Valley screen after preliminary refining of the pulps, indicating that the disk mill treatment provided adequate defibering. In most cases, the caustic was almost completely consumed; sulfide consumption varied from 60 to 96%. The conditions selected also resulted in a considerable range of values for yield, ease of refining, permanganate number, and strength properties of the sheets. Consequently, on the basis of these data one can select the better materials and eliminate the poorer ones, assuming that differences demonstrated are characteristic of the raw materials rather than of variable response to processing. This supposition seems reasonable since the kraft cooking procedure used tends to produce strong pulps with many different types of raw material (*4*) and since the drainage characteristics of the refined pulps were fairly constant and in a range that normally results in good overall strength development.

Favorable results were obtained on some of the mallows, particularly okra and kenaf. Louisiana-grown okra (nos. 16 and 17 in Table I) provided a good yield of pulp which was readily refined to provide sheets of excellent strength properties, approaching those of woods. Permanganate numbers indicate that bleaching should not be excessively difficult. The favorable strength properties are consistent with previous analytical findings (*1*) that okra stalks contain longer fibers in their woody core than other dicotyledonous plants examined. Pulp yield from Nebraska-grown okra (no. 58) was low but folding endurance and bursting strength were high. Roselle (no. 22) and velvet weed (no. 10) also gave pulp handhseets in the upper range of strength properties.

Among the legumes, sunn hemp grown in Texas (nos. 11 and 15) provided the strongest pulps. Other *Crotalarias* and the *Sesbania* sample (no. 7) gave pulps having intermediate strength properties.

Some members of the grass family also furnished pulp samples of high and intermediate handsheet strengths. Grasses that provided high-strength pulps were *Stipa* (no. 61), *Lygeum* (no. 53), *Gynerium* (no. 29), bamboo (no. 31), *Sorghum almum* (no. 28), and two millets (nos. 32 and 35). Pulps intermediate in quality include the various *Sorghum vulgare* samples, *Andropogon* (nos. 44 and 52), and *miscanthus sinensis* (no. 45). Stipa viridula (no. 61) did not provide high pulp yield but its quality was sufficiently good to warrant the testing of additional samples.

Aside from castor stalks (no. 26) which provided fair strength qualities, the remaining samples gave pulps inferior in strength to those mentioned.

Chemical analyses of selected pulps and their parent raw materials are listed in Table II. Two important differences between dicotyledons and grasses can be noted: (a) dicotyledonous pulps have lower pentosan contents, and (b) grasses show a greater extent of delignification. The first appears due to differences in original percentage composition of the stalks, since recoveries are similar; and the second to varying response to pulping chemicals. Cellulose contents and recoveries are comparable for grasses and dicotyledons. *Stipa tenacissima* (no. 3) and *Hibiscus sabdariffa* (no. 22) are exceptional species, the former having unusually high cellulose content and the latter especially low pentosan content.

DISCUSSION

Individual plant species with specific characteristics may be selected from the data presented in Tables I and II. However, a comparison of properties among groups of samples to determine general tendencies is best made by statistical treatment of the data. Such a comparison was made, using both pulping data from this paper and analytical data on the raw materials as iisted in earlier papers of this series (*1*, *2*) or since determined by the same analytical methods.

Comparison of Analyses and Pulp Properties Among Different Botanical Groups

A statistical *t* test (*5*) was used to assess the significance of the differences among selected botanical groupings (Table III). Standard wood samples were excluded in calculations. The *t* test is a comparison of averages, based on probability, which takes into account the variability and number of the values making up the average. Comparisons are not necessarily among botanical groupings of equal "rank"; yet the subdivisions used are appropriate for analyzing the pres-

Table II. Chemical Composition of Selected Pulps and Their Parent Raw Materials[a]

Sample no.	Material	Stalk composition, % M.E.A.[b] cellulose	Stalk composition, % α-cellulose	Stalk composition, % Pentosans	Stalk composition, % Lignin	Pulp composition, % M.E.A. cellulose	Pulp composition, % α-cellulose	Pulp composition, % Pentosans	Pulp composition, % Lignin	Constituent recovery, % M.E.A. cellulose	Constituent recovery, % α-cellulose	Constituent recovery, % Pentosans	Constituent recovery, % Lignin
					Grasses								
3	*Stipa tenacissima*	60.5	47.8	22.8	13.9	96.1	83.2	15.8	1.3	85.1	93.3	57.5	5.0
13	*Sorghum vulgare* PQX65584	52.8	34.2	25.8	16.0	83.6	61.0	25.7	9.5	88.2	99.3	55.4	33.0
28	*Sorghum alum*	54.9	36.3	26.4	14.4	89.7	65.5	27.9	3.2	82.8	91.4	53.5	11.3
29	*Gynerium sagittatum*	58.4	38.5	25.2	23.2	90.2	68.3	23.4	7.1	77.7	89.3	46.7	15.4
31	*Phyllostachys bambusoides*	58.1	34.8	28.5	23.0	85.9	62.1	25.7	9.4	73.5	88.7	44.9	20.3
35	*Pennisetum typhoides*	49.2	31.7	28.6	15.9	87.3	62.0	29.2	4.4	86.0	94.8	49.5	7.4
44	*Andropogon gerardi*	52.2	33.4	30.2	17.4	88.5	62.7	30.3	3.6	80.7	89.4	47.7	9.9
61	*Stipa viridula*	47.2	29.4	20.2	17.0	87.8	61.7	28.4	3.8	72.1	81.4	54.5	8.7
					Dicotyledons								
12	*Crotalaria juncea*	54.1	37.9	18.4	21.4	80.4	64.9	15.2	14.3	81.8	95.7	46.2	37.4
17	*Hibiscus esculentus* (Louisiana green velvet)	53.4	35.1	21.1	20.1	83.4	64.5	19.1	9.5	85.6	100.7	49.6	25.9
18	*Hibiscus cannabinus* variety 52-41	53.3	36.0	21.5	17.8	81.8	63.5	17.2	12.6	83.8	96.3	43.7	38.7
22	*Hibiscus sabdariffa*	48.6	32.1	13.0	15.6	76.7	59.2	18.1	15.8	83.8	97.9	73.9	53.8
23	*Crotalaria intermedia*	54.8	38.1	20.4	20.6	81.8	65.0	16.6	15.0	79.1	90.4	43.2	38.7
26	*Ricinus communis*	49.7	34.0	18.6	19.0	75.6	60.0	15.4	16.7	79.3	91.9	43.1	46.8

[a] All analyses on moisture-free basis.
[b] Monoethanolamine.

ent data. For example, dicotyledons other than mallows and legumes were combined into a heterogenous group called "other dicotyledons" so that remaining samples could be included for consideration. However, the comparisons between "other dicots" and grasses, mallows, and legumes may be of limited value since the species of "other dicots" represent only four widely different families and cannot be considered representative of any large group.

Alpha-cellulose content of all samples was characterized more by similarity than by difference. This is also true of stalk maceration yield, sulfide consumed in pulping, and tear resistance of pulp handsheets.

Alkali solubility, on the other hand, showed very distinct differences, indicating compositional dissimilarities among the plant groups. Differences in pulp yield parallel quite closely differences in alkali solubility. This similarity might be expected since an alkaline pulping procedure was used. Thus, for comparison between groups the empirical alkali

Table III. Statistical Comparison of Average Values for Analyses and Properties of Species from Different Botanical Groups (*t* test)

Factor compared	Grasses vs. Dicots	Grasses vs. Mallows	Grasses vs. Legumes	Mallows vs. Legumes	Grasses vs. "Other"[c] Dicots	Mallows vs. "Other"[c] Dicots	Legumes vs. "Other"[c] Dicots
	Significance[a] and (average values ± standard deviation)[b]						
α-Cellulose content of raw material	NS (32.1 ± 4.3; 32.8 ± 4.0)	NS (32.1 ± 4.3; 33.4 ± 4.7)	* (32.1 ± 4.3; 34.9 ± 2.8)	NS (33.4 ± 4.7; 34.9 ± 2.8)	NS (32.1 ± 4.3; 30.3 ± 2.7)	*− (33.4 ± 4.7; 30.3 ± 2.7)	** (34.9 ± 2.8; 30.3 ± 2.7)
Alkali solubility of raw material	** (42.7 ± 5.3; 34.7 ± 4.6)	** (42.7 ± 5.3; 35.2 ± 5.4)	** (42.7 ± 5.3; 32.5 ± 3.6)	NS (35.2 ± 5.4; 32.5 ± 3.6)	** (42.7 ± 5.3; 36.2 ± 4.1)	NS (35.2 ± 5.4; 36.4 ± 4.1)	* (32.5 ± 3.6; 36.2 ± 4.1)
Fiber length of raw material	NS (1.17 ± 0.21; 1.09 ± 0.27)	** (1.17 ± 0.21; 1.35 ± 0.13)	** (1.17 ± 0.21; 0.94 ± 0.09)	** (1.35 ± 0.13; 0.94 ± 0.09)	* (1.17 ± 0.21; 0.95 ± 0.27)	** (1.35 ± 0.13; 0.95 ± 0.27)	NS (0.94 ± 0.09; 0.95 ± 0.27)
Fiber width of raw material	** (12.9 ± 1.89; 25.0 ± 5.68)	** (12.9 ± 1.89; 29.5 ± 4.44)	** (12.9 ± 1.89; 23.2 ± 5.05)	** (29.5 ± 4.44; 23.2 ± 5.05)	** (12.9 ± 1.89; 21.5 ± 4.17)	** (29.5 ± 4.44 21.5 ± 4.17)	NS (23.2 ± 5.05 21.5 ± 4.17)
Maceration yield	NS (51.4 ± 4.2; 51.7 ± 6.0)	NS (51.4 ± 4.2; 53.4 ± 5.6)	NS (51.4 ± 4.2; 51.7 ± 6.5)	NS (53.4 ± 5.6; 51.7 ± 6.5)	NS (51.4 ± 4.2; 50.0 ± 6.2)	NS (53.4 ± 5.6; 50.0 ± 6.2)	NS (51.7 ± 6.5; 50.0 ± 6.2)
Pulp yield	** (46.8 ± 4.0; 52.9 ± 4.2)	** (46.8 ± 4.0; 52.8 ± 4.9)	** (46.8 ± 4.0; 55.2 ± 2.8)	NS (52.8 ± 4.9; 55.2 ± 2.8)	** (46.8 ± 4.0; 51.0 ± 3.8)	NS (52.8 ± 4.9; 51.0 ± 3.8)	** (55.2 ± 2.8; 51.0 ± 3.8)
Sulfide consumed	NS (78 ± 10.6; 83 ± 9.3)	** (78 ± 10.6; 86 ± 5.0)	NS (78 ± 10.6; 81 ± 11.0)	NS (86 ± 5.0; 81 ± 11.0)	NS (78 ± 10.6; 82 ± 11.0)	NS (86 ± 5.0; 82 ± 11.0)	NS (81 ± 11.0; 82 ± 11.0)
Refining time	NS (183 ± 117; 191 ± 128)	** (183 ± 117; 112 ± 13)	** (183 ± 117; 324 ± 143)	** (112 ± 13; 324 ± 143)	*− (183 ± 117; 134 ± 43)	NS (112 ± 13; 134 ± 43)	** (324 ± 143; 134 ± 43)
Permanganate number	** (26.4 ± 11.5; 58.6 ± 5.7)	** (26.4 ± 11.5; 55.7 ± 6.1)	** (26.4 ± 11.5; 58.2 ± 3.2)	NS (55.7 ± 6.1; 58.2 ± 3.2)	** (26.4 ± 11.5; 62.2 ± 5.3)	* (55.7 ± 6.1; 62.2 ± 5.3)	NS (58.2 ± 3.2; 62.2 ± 5.3)
Burst	*− (73.8 ± 14.9; 65.5 ± 20.4)	* (73.8 ± 14.9; 83.0 ± 10.6)	NS (73.8 ± 14.9; 67.0 ± 15.9)	* (83.0 ± 10.6; 67.0 ± 15.9)	** (73.8 ± 14.9; 45.0 ± 12.3)	** (83.0 ± 10.6; 45.0 ± 12.3)	** (67.0 ± 15.9; 45.0 ± 12.3)
Tear	NS (72.1 ± 34.5; 77.3 ± 15.4)	NS (72.1 ± 34.5; 75.9 ± 10.4)	NS (72.1 ± 34.5; 83.0 ± 17.4)	NS (75.9 ± 10.4; 83.0 ± 17.4)	NS (72.1 ± 34.5; 73.5 ± 17.8)	NS (75.9 ± 10.4; 73.5 ± 17.8)	NS (83.0 ± 17.4; 73.5 ± 17.8)
Fold	* (154 ± 163; 259 ± 247)	** (154 ± 163; 460 ± 213)	NS (154 ± 163; 229 ± 193)	* (460 ± 213; 229 ± 193)	*− (154 ± 163; 67 ± 131)	** (460 ± 213; 67 ± 131)	* (229 ± 193; 67 ± 131)

[a] ** Highly significant (99% probability); * significant (95% probability); *− significant (90% probability); NS, not significant.
[b] Values in parentheses are in order of column heading and in units previously used.
[c] "Other" than mallows and legumes.

solubility determination provides a better index of pulp yield than the more fundamental alpha-cellulose content of the raw material. In pulping, noncellulosic constituents are removed to differing extents. It will be shown in the next section that *within* botanical families relationships between alkali solubility and pulp yield vary in degree of significance.

Statistically significant differences in fiber dimensions are apparent when families are compared with one the grasses. Refining time did not seem necessarily related to sulfide consumed. Permanganate number is generally considered to be related to extent of delignification, and hence to completeness of pulping. One might expect, then, that materials with the highest permanganate number would furnish the highest yields. Data in Table III indicate this tendency, showing that the selected pulping conditions resulted in considerably more complete pulping of grasses

Table IV. Statistical Relations Among Properties of Raw Materials and Pulps

Relation calculated	*Significance of relationships among properties (% of variation accounted for in parentheses)*[a]					
	Pulping data				*Raw material analyses*	
	Pulp yield	*Burst*	*Tear*	*Fold*	*α-cellulose*	*Alkali solubility*
			Grasses			
Simple Correlations[b]						
Raw material anslyses:						
1. α-cellulose	** (42+)	** (35+)	** (56+)	** (66+)	...	** (51−)
2. Alkali solubility	*− (13−)	* (17−)	** (41−)	** (29−)	** (51−)	
3. Yield on stalk maceration	** (23+)	...	...	...	*− (10+)	* (19−)
4. Average fiber length	...	NS (0.5+)	NS (3+)	NS (0.1+)	...	...
5. Average fiber width	...	NS (5−)	NS (2−)	NS (6−)	...	...
6. Length: width ratio	...	NS (7+)	NS (9+)	NS (6+)	...	...
7. Average length of all cells[c]	...	NS (3+)	NS (8+)	NS (2+)	...	...
Pulping data:						
8. Pulp yield	...	* (15+)	*− (13+)	**(25+)	** (42+)	*− (13−)
9. Permanganate number	NS (1+)	* (15−)	NS (5−)	NS (9−)	...	...
10. Tear	...	** (34+)	...	** (66+)	...	...
11. Fold	...	** (62+)	** (66+)	...	...	...
Multiple correlations[d]/						
2 and 3 together	** (50)	...	...	...	...	...
1 and 6 together	...	...	** (58)	...	...	...
			Dicotyledons			
Simple correlations[b]/						
Raw material analyses:						
1. α-cellulose	** (60+)	** (21+)	** (23+)	* (14+)	...	** (69−)
2. Alkali solubility	** (68−)	NS (7−)	* (16−)	NS (7−)	** (69−)	...
3. Yield on stalk maceration	* (12+)	...	...	...	** (36+)	** (22−)
4. Average fiber length[e]	...	** (28+)	NS (2+)	** (29+)	...	...
5. Average fiber width[e]	...	** (36+)	NS (4+)	** (45+)	...	...
6. Length: width ratio	...	NS (0.2−)	NS (0.2−)	NS (1−)	...	...
7. Average length of all cells[c]	...	* (19+)	NS (8+)	** (20+)	...	...
8. % Bast fiber	...	* (23+)	NS (3+)	*− (12+)	...	...
9. Bast fiber length	...	** (32+)	** (36+)	** (26+)	...	...
Pulping data:						
10. Pulp yield	...	*− (10+)	* (14+)	NS (6+)	...	...
11. Permanganate number	NS (0.3+)	** (20−)	*− (11−)	** (24−)	...	...
12. Tear	...	NS (2+)	...	NS (0.3+)	...	...
13. Fold	...	** (79+)	NS (0.3+)	...	...	...
Multiple correlations[d]						
1 and 2 together	** (70)	...	...	...	...	...
1 and 4 together	...	** (41)	* (23)	** (37)	...	...
4 and 5 together	...	** (40)	NS (4)	** (47)	...	...
1, 4, and 5 together	...	** (47)	* (23)	** (49)	...	...

[a] ** Highly significant (99% probability); * significant (95% probability); *− significant (90% probability); NS, not significant. Values in parentheses indicate the percentage of the total variability accounted for in each comparison. The sign following the percentage figure indicates whether the relationship is direct (+) or inverse (−).

[b] For calculation of the simple correlation coefficient, r, see reference (*5*).

[c] Includes fibers and all other cells present 0.1 mm. or longer.

[d] Multiple correlation coefficients were determined by matrix inversion. See reference (*6*).

[e] For dicotyledons mathematically combined average lengths and widths were used [see reference (*1*)], which included dimensions of bast and woody core fibers.

another; however, fibers of these dicotyledons as a group, differ significantly from grasses in width but not in length. Average fiber lengths found are in the order mallows > grasses > legumes and widths in the order mallows > legumes > grasses.

Mallows refined more easily than grasses and appreciably faster than legumes. However, since ease of refining varied so greatly among these dicotyledons, no significant difference exists between them and than of the dicotyledons. Within the latter group, response to pulping was fairly uniform. Meaningful comparisons might be obtained from experiments which included either a less drastic pulping of grasses or a more drastic treatment of dicotyledons to effect more nearly equivalent removal of noncellulosic constituents. Mallows were more easily refined than grasses, despite the lesser extent of delignification.

We wondered if chemical consumption might be

related either to ease of refining or to extent of lignin removal. However, sulfide consumption under these experimental conditions did not consistently parallel either refining time or permanganate number.

In comparing handsheet strengths, probably the most important observation is the high average fold and burst values for mallows, certainly a plus value in their consideration as papermaking materials.

Correlations Among Properties of Raw Materials and Pulps

Table IV presents simple and multiple correlations, calculated by standard procedures (*5*, *6*), among certain properties of the pulps and of their parent raw materials. In contrast with statistical data of the preceding section, these calculations pertain to the validity of interrelations among properties within a botanical grouping rather than to a comparison of averages between groups. Further subdivision of dicotyledons would be desirable, but must be left for future work since the number and types of present samples did not warrant such separation.

The simple correlation coefficient, r, is a measure of the magnitude of the relationship existing between two related variables. The percentage of the total variability of the dependent variable accounted for by the independent variable is determined by calculating $r^2 \times 100$. Whether a relationship is statistically significant is dependent on the magnitude of r and the number of samples used in determining r. With small samples, r must be fairly large before probability theory will predict that the relationship is significant or real, and not merely caused by chance. However, if a relationship is classified as nonsignificant because only a few samples were available for analysis, examination of r, or $r^2 \times 100$, may *suggest* that with more samples the relationship *might* become significant.

Important deductions which may be drawn from Table IV include the following:

1. Alpha-cellulose content of a raw material would serve as the best single criterion for predicting both pulp yield and pulp quality of a given species.

2. Alkali solubility is more closely correlated with pulp yield for dicotyledons than for monocotyledons. Conversely, it is more closely related to strength properties for monocotyledons than dicotyledons. This, along with differences noted in the t tests, suggests that the alkali solubility is a measure of different characteristics or composition in these two plant types.

3. The literature (*7–9*) leads one to believe that there is a fairly definite relationship between fiber length or length:width ratio and strength properties of derived papers, especially tearing resistance. This is a reasonable expectation, found valid in practical operations. However, results on the present raw materials do not entirely confirm the general existence of such a relationship. It could not be demonstrated at all for monocotyledons, and it was valid only for length and width individually related to burst and fold for dicotyledons. Bast fiber length for the latter is significantly related to all three handsheet strength characteristics.

The fact that fiber dimensions do not correlate as significantly with strength properties as expected may be attributed to four factors: (a) fiber dimensions of the pulps might be substantially different from those of the raw material; this does not appear to be true in the several instances in which the point was checked because very little fiber breakage or damage was evident in these pulps. (b) Fiber dimensions are not the only raw material characteristics that affect paper strength; characteristics such as inherent fiber strength (*10*), fiber flexibility, wall thickness, ease of fibrillation, and fiber bonding in the sheet are also important. Unfortunately, the contribution of fiber dimensions alone to paper strength cannot be dissociated from the effect of these other characteristics. It appears that, for monocotyledons, these other characteristics are more important than fiber dimensions since no significant correlations with fiber dimensions were found. (*c*) It is doubtful if maximum strength was developed in refining these pulps by our simplified procedure. The dicotyledons show highly significant correlations of fiber length and width with burst and fold strengths, but not with tear. Perhaps refining of dicotyledons came closer to developing maximum burst and fold strengths so that the effect of fiber dimensions on these properties is apparent. Refining may have exceeded the optimum for tear, thus masking any possible significant correlation with fiber dimensions. (d) The ranges of fiber dimensions represented may not have been adequate for demonstrating dimension-strength relationships.

4. In monocotyledons a sheet good in one strength property is likely to be of high quality in other properties as well; whereas with dicotyledons, tear resistance appears to be independent of folding and bursting strength.

5. Lignin content of pulps (as indicated by permanganate number) is not significantly related to yield in either group but is related to burst for monocotyledons and burst, tear, and fold for dicotyledons.

6. The multiple correlations presented indicate additive contributions by fiber length and width to predictions of burst and fold strengths based on alpha-cellulose content among the dicotyledons.

CONCLUSIONS

The work presented demonstrates the considerable value of the approaches taken in comparative evaluation of plant raw materials, and especially of the statistical treatment of data. The sampling, consisting of about 60 raw materials, is small, particularly since multiple sampling within certain few genera and families was common. The botanical groups used as a basis for comparison may have been sufficiently nonhomogeneous to make further subdivision desirable, but the number of samples on which data are presently available is insufficient to warrant this more valid approach. Hence, future work should include acquisition of similar data on a much larger number of materials to ascertain whether the generalizations indicated here can be substantiated and extended.

The data confirm that large qualitative differences exist between grasses and dicotyledonous plants in properties and response to pulping chemicals. Much needs to be known about the basic chemistry responsible for these differences. From a practical standpoint, attention must be given to differences in processing that will permit production of quality pulps in highest yield from both groups of materials.

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A Method of Economic Analysis of the Papermaking Process

S. G. HOLT

A method of economic analysis has been proposed which appears to be particularly suitable for analyzing papermaking processes. Several examples to typical analyses are given together with some tentative conclusions on the affect of various design factors. Two methods of comparison are discussed. One involving a "vertical cross-section" is applied to a single production line. The second method, called a "horizontal cross-section" is particularly suited to comparing similar production processes or production steps. The concept of added value per unit operation is used as the economic unit. Tentative conclusions are that paper machine efficiency is a major factor in determining papermaking costs. It is shown that efficiency is strongly affected by machine speeds with machines over 120 in. wide It is further proposed that paper machines be constructed to operate on known technology at high efficiencies.

THE SIGNIFICANCE of cost in a manufacturing operation need not be explained. The use, however, of cost data in analyzing technical processes in a multiline or multimachine operation, for the purpose of evaluating manufacturing techniques and the economic potentialities of equipment, is not as clearly understood. Furthermore, the development of economic methods for analysis have been handicapped by the lack of a standard terminology or jargon. Consequently, economic comparisons between various divisions and firms must be given in considerable detail. This fact, together with the natural reluctance of competitors to reveal financial information has made progress even more difficult in the field of technical economics.

It is hoped that there can eventually be some agreement on certain methods and terminology which will facilitate intercompany exchanges of information without revealing details of corporate management.

The attempt has been made to establish a method for analyzing papermaking processes from the standpoint of "technical economics." This method could be applied to a wide variety of manufacturing processes. It has been found that two fairly simple concepts can be used to make comparisons which are meaningful and reasonably obvious. These methods or concepts are not those commonly used in cost accounting. They have, however, the virtue of being understandable to cost control, technical, and manufacturing personnel. It is also believed that this method can be used to illustrate the application which economic analysis has to corporation planning, research and development effort, and the purchasing or modernizing of equipment.

The use of economic methods for orienting research and development effort is one which is occasionally discussed in general principles, but it remains a field of application about which there is relatively little published information at present. Maximum results from a given amount of research and development expenditure depend to a large extent upon a sound knowledge of the economics of the processes being studied, as well as an understanding of the various physical and chemical principles involved. This fact was the original reason for carrying out this type of investigation.

In most corporations, it is generally difficult to obtain good "engineering-economic" data in readily usable form to guide company officers, R&D, engineering, etc., in making executive decisions. Company officers are frequently faced with the problem of determining manufacturing and maintenance costs and comparing additional expenses with possible cost savings by changes in equipment and techniques. It is believed that this engineering-economic data, if expressed in the proper terms, can be applied directly to two basic types of problems:

1. Obtaining realistic estimates of the economic potential of:
   (a) Changes in methods and equipment.
   (b) New products.
   (c) New decision-making aids.
   (d) New but related lines of business.
2. Delineate research and development goals by pointing up:
   (a) Areas and operations with good potential for increased efficiency and/or lower costs.
   (b) Pointing out cost trends due to changes in technology, product line, raw material costs, markets, etc.

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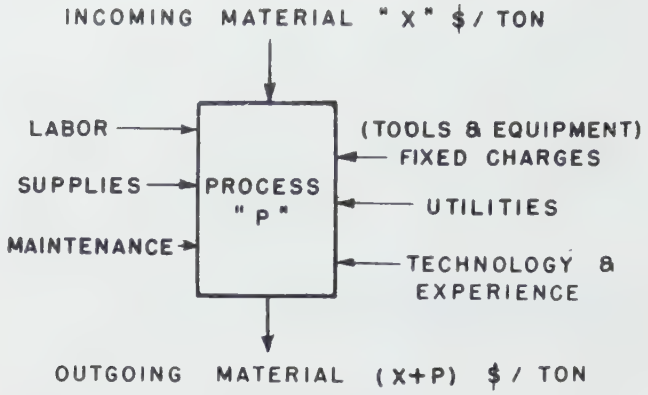

Fig. 1. Diagram of a single "operation" showing the value added during the process P

THE ADDED VALUE CONCEPT

A concept which has proved useful for this type of analysis is to consider each increment of an operation or process to be one where definable value is added to the product. In Fig. 1 a square is drawn representing one "operation." Into this operation proceeds the raw or incoming material. During the operation inside the box, the incoming material is acted upon by labor, tools, utilities (such as heat, electricity, light, etc.), as well as technology and skills relevant to the operation. It thereby acquires an added value which is equal to the direct costs of the operation performed together with the fixed and overhead charges (associated with the capital investment involved equipment necessary to perform this operation).

It is, in general, possible to break any industrial process down into a series of "operations" for which an analysis of the type described above can be performed.

Operations as defined above can easily be combined to form larger or more inclusive combined operations by simple addition. Operations can also be divided into smaller units although, generally, with some difficulty because more detailed information is required.

CROSS-SECTIONS OF PRODUCTION PROCESSES

A frame of reference has been adopted which seems to be a useful concept in systematizing economic data. It is a sort of "contour map" of the process. Each production line or unit is shown as a vertical column which is started with the cost of the raw material for the particular line. Under it are shown a series of boxes representing the subsequent operations or stages. For each of these stages or boxes, representing a certain operation in a certain mill or plant, the value added by the particular operation can be determined and combined with the previous value of the raw material or in-process material, to give the actual cost of the in-process material at that stage.

The cost of each operation has been broken down under the following headings:

1. Fixed charges—based on the original cost of the equipment and useful life.
2. Operating overhead—including: administrative cost, technical services, insurance, research and development, engineering, security service, etc.
3. Supplies and materials—all materials and supplies which are not maintenance or raw materials.

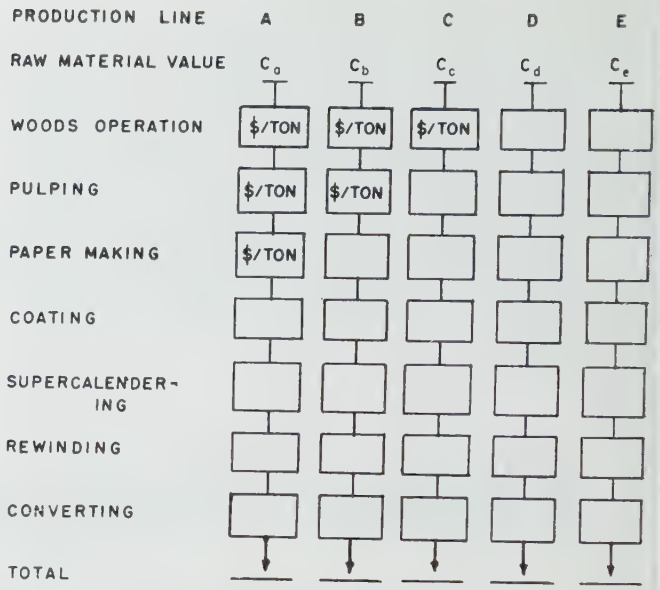

Fig. 2. Diagram of a "frame of reference" for analyzing a multiline coated-paper mill

4. Operating labor—including labor overhead, fringe benefits, cafeteria, bonuses, insurance, etc.
5. Maintenance—parts and labor.
6. Utilities—water, electricity, steam, gas, etc.
7. Transportation—includes all shipping, material handling, and warehousing.

Figure 2 shows a diagram which might be used to analyze a series of coated-paper mills. The vertical columns, each indicating an individual, production line, machine, mill, etc., have been divided into a series of steps or "operations." These operations correspond to various identifiable operations which are represented by a "box." Each box shows the total value added to the product in the operation. Similarly, each row shows the costs of doing the same or similar process in a number of different producing units. This type of cross-comparison is most useful in comparing alternate processes, types of equipment, and efficiency of plant operations.

Although it would be desirable to place the proper dollar value representing the value increment for each process in each production line, this frequently becomes a difficult and burdensome task. It has been found that by determining several selected "cross-sections," it is usually possible to characterize and better understand this process "matrix" without evaluating each individual function. Sections taken vertically and which will be called "Vertical Cross-Sections" represent the cost increments, and hence, the cost build up from the basic raw material through each of the manufacturing processes down to the final finished product. A vertical cross-section, particularly when carried out in detail, is usually quite informative even for a single process line whose technology is familiar.

Reluctance to publish actual data makes it necessary to show a typical but synthetic vertical cross section of a 10-year-old paper machine making creped tissue. It was found that the best and most reliable method is to use an auditing procedure wherein each cost, chargable to the "line," is allocated into its proper area or operation. This has been done, at considerable labor, for several machines to determine suitable

techniques and workable compromises where no exact information could be found.

It should be remembered that in many cases production lines are not a simple vertical arrangement from the tree to the paper merchant's warehouse and that there is a pattern of many branches and recombinations proceeding toward the final product. For instance, wood from several sources will pass through several different pulp mills, into the final sheet. Such items as clay, starch, dyes, will proceed from widely scattered sources into the final product.

Even though approximations are often necessary, the definition of the vertical cost structure is very helpful in obtaining a perspective of the production line under analysis. The techniques for determining the information necessary to construct the vertical cost cross section will depend to a large extent upon the bookkeeping and accounting records available.

DISCUSSION OF THE VERTICAL CROSS-SECTION

Table I is a fairly detailed breakdown of the cost involved in making and converting creped tissue, which is typical, but not actual, data. For the purpose of illustrating the method, the exact details are not important. Inasmuch as these are representative figures, it is quite interesting to look at them individually and discuss the possible implications. The final cost of $200 per ton was chosen arbitrarily.

Woods Operation. Assuming the basic raw material to be stumpage, it will be noted that the woods operation costs are quite large in comparison. In general, woods operations are difficult to examine because of the wide variations in conditions. Wood from remote locations is relatively cheap as far as stumpage is concerned but involves higher cutting and transportation costs. Conversely, wood located close to the point of consumption is higher priced but involves lower handling and cutting charges. The investment in the equipment for woods operation is currently quite small but gaining rapidly. It will be noted that a large part of the cost for the example given is direct labor, overhead, and transportation.

Pulping. The pulping cost for an operation like this must necessarily consist of a series of combinations as several pulps are blended into the final finish. In general, it can be said that the investment is high and that the large cost items are direct supplies, fixed charges, and overhead.

Papermaking. Papermaking costs have been broken down into three sections: (1) formation, (2) pressing, and (3) drying. One of the purposes of this type of analysis is to obtain a good perspective of costs and the papermaking operations. Consequently, a detailed investigation of this step has been carried out.

By definition, formation costs are those accumulated from the stock chests to the bottom couch roll. Press costs cover the process from the top couch roll (if used) through to the drier section. Drying costs are those from the time the sheet first meets the drier section until it is wound up on the reel.

Looking first at overall costs, it is usually found the formation and drying represent almost equal cost increments. The higher cost of the pressing operation is a distinct departure from conventional opinions. In seeking the cause for this, it is interesting to note

Table I. Vertical Cross-Section of a Paper Production Line

Woods operation	*Value/ton product (arbitrary)*		*Investment/ ton/year*
Stumpage		4.85	
Cutting prime costs			21.00
Fixed charges	1.94		
Operating overhead	10.64		
Supplier and materials	3.94		
Operating labor	11.99		
Maintenance	4.16		
Transportation	11.22		
Woods operation total		43.89	
Pulping			110.10
Fixed charges	11.50		
Operating overhead	3.05		
Supplies and materials	12.75		
Operating labor	3.10		
Maintenance	2.03		
Utilities	8.45		
Transportation	1.05		
Pulping total		41.93	
Papermaking			
Formation section (cost $675,917.)			31.50
Fixed charges	2.15		
Supplies	2.80		
Operation labor	1.18		
Maintenance P & L	1.25		
Overhead	2.70		
Utilities	2.28		
Subtotal	12.36		
Press section (cost $401,368.)			18.10
Fixed charges	1.26		
Supplies	3.48		
Operating labor	1.24		
Maintenance P & L	.98		
Overhead	1.98		
Utilities	5.60		
Subtotal	14.58		
Drying section (cost $628,154.)			25.50
Fixed charges	2.03		
Supplies	.46		
Operating labor	2.27		
Maintenance P & L	.99		
Overhead	2.73		
Utilities	3.46		
Subtotal	11.94		
Papermaking total		38.84	
Converting			15.80
Fixed charges	2.32		
Operating overhead	4.45		
Supplies & materials	21.50		
Operating labor	11.56		
Maintenance	3.85		
Utilities	0.19		
Converting total		43.87	
Grand total for production line		$200.00	
Total investment			222.00

that the fixed charges are higher for formation and drying, and that the large items for the pressing operation are mostly for supplies (felts, felt cleaning, roll coverings, etc.) and utilities. High utility costs (steam, water, and electric power) are not generally anticipated in press section operations. Analysis of several paper machines has shown that the steam costs for the press section can be 40% greater than that used in the drier section. This situation is probably the result of small changes over a long period. It is rather common practice to push machines for maximum production. One of the easiest ways of doing this is to use more heat in the shower water to improve the dryness out of the press. This is not recommended as an economical procedure but it is one where improved production can be bought for a price.

Converting Costs. One point seems to stand out in these costs. The total labor, which includes both direct labor and maintenance, is about twice that for the

entire papermaking operation. It is recognized that converting operations, in general, are more of a start-and-stop nature than papermaking which could be characterized as a bulk or "straight-through" process. On the other hand, it is apparent that for approximately the same gain in product value, converting has only about one-fourth as much of an investment in equipment. While no definite judgments can be made, the question of why there is such a large difference in relative investment between these two operations is a good one. It would seem advisable to either invest more in the converting operation in order to reduce the operating costs or to do the opposite to the papermaking process. It also becomes evident that much of the value of this exploratory type of economic analysis is in the questions which are raised and which will require further investigation.

Cost–Investment Relationships. There is good reason to believe that a general relationship should exist between investments, fixed charges, labor, and maintenance. A pattern which occurs frequently in this type of analysis is to find operating and maintenance costs high in operations where investment is low. This probably means that the operation where investment is low is one which cannot be easily mechanized (the woods operation for instance) or one which has not been developed to the usual level. A third condition that bears on the problem is one where the type or details of a process change rapidly to suit market, raw material, or other variable conditions. Consequently, development of equipment is likely to lag behind current needs. The pulp mill probably represents an opposite situation to that discussed above with its high investment and relatively low operating costs and stable product line.

In the papermaking operation, the press section has an appearance of an underdeveloped operation with a high operating cost and relatively low investment. This is not to imply that enough money is not being spent on press sections or that they are not sufficiently complicated. It may well be that we do not know at present how to design a really good press and that the present design is one which is being "forced" by lavish use of heat and vacuum.

DISCUSSION OF THE HORIZONTAL CROSS-SECTIONS

Where it is possible to find several machines or processes making identical or similar products, it is informative to construct a horizontal cross-section of the operations. In addition, it usually becomes quite rewarding to examine in detail some of the cost constituents on this same comparison basis. Table II shows a horizontal cross-section for five imaginary but typical paper machines (Corporation security makes if difficult to get clearance for actual machines.) The cost patterns shown are typical and illustrate some interesting trends.

The following comments may help in understanding some of the differences shown in the table:

A is a narrow machine approximately 40 years old, of simple design.

B is a machine of moderate speed and width, approximately 25 years old.

C is a relatively narrow, high-speed machine, approximately 15 years old.

D is a fast and modern machine approximately 12 years old, which is a further development of machine *B*.

Table II

	Paper machine				
	A	*B*	*C*	*D*	*E*
Trim, in.	100	160	100	160	190
Speed, f.p.m.	1524	1460	2500	2300	2300
Approximate age, yr.	40	25	15	12	5
Efficiency, %	87	84	80	73	72
	Dollars/ton × code factor				
Fixed charges	12.72	12.00	13.20	36.70	39.16
Overhead	5.80	6.45	4.68	2.99	5.10
Supplies & labor	34.88	43.60	28.12	44.10	35.74
Maintenance	16.05	17.50	18.61	16.50	14.80
Utilities	29.50	33.00	28.51	31.95	27.07
Total	98.95	112.55	93.12	132.24	121.87

E is a high-speed machine similar in design to *D* but somewhat simpler, and is approximately 5 years old.

The combination item "supplies and labor" involves direct labor charges and papermaking supplies such as felts, wires, and other items used directly by the machine crews.

Utilities are: water, steam, and electricity.

Fixed charges are: the carrying charges on the investment, and are a direct function of the newness of the machine and the total amount of investment. New expensive machines carry the heaviest fixed charges.

Efficiency is: a term involving the production achieved relative to that which would have been achieved if the machine operated 100% of the scheduled time at its usual speed.

From Table II, several factors seem to be evident. The papermaking total—labor and expense—appears to be closely related to the efficiency of the operation. Machines *A*, *B*, and *C*, having efficiencies of 80% or better, appear to be either narrow machines or, in the case of *B*, relatively slow. The two wide machines *D* and *E*, operating at approximately the same speed, show the poorest overall efficiencies and highest papermaking costs.

Some of the possible reasons for this will be examined briefly later. Machines *A* and *B*, being the oldest and probably the least expensive of the group, show the smallest fixed charges as would be expected. It is quite interesting to note that machine *C*, although it operates at quite high speeds, demonstrates a low fixed charge and low investment capital compared to the newer machines *D* and *E*.

Looking at papermaking costs involving wires, felts, and direct papermaking labor, it is interesting to note that *C* has a clear lead in this department. It would seem to indicate that a narrow machine operating at a relatively high speed is capable of producing enough paper to keep labor charges down and apparently is able to do this at a moderate cost in wires, felts, and other supplies. This argument will be developed later under a discussion of width and speed. Machine *D* is a development of machine *C* and there appears to be a trend toward higher papermaking costs; although this was successfully reversed in *E*.

In view of the fact that machine investment was increased in going from *C* to *D* and *D* to *E*, it would be expected that this expenditure would be partially compensated by reduced papermaking expenses. The fact that this was not accomplished would indicate that the changes made between machines *C* and *D* or *E*

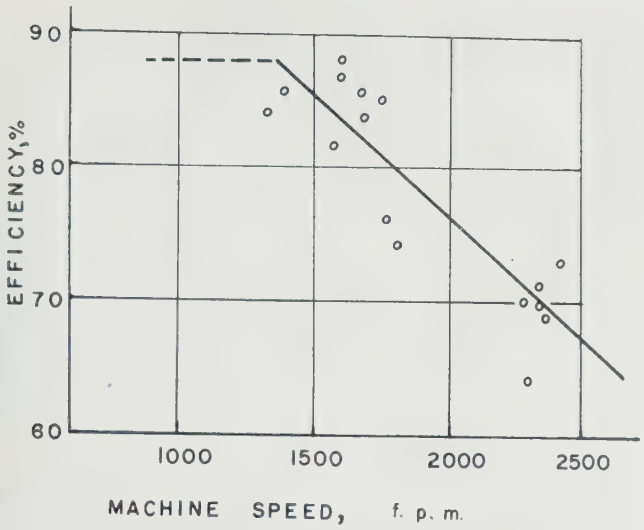

Fig. 3. Machine efficiency versus machine speed for machines over 122 in. wide

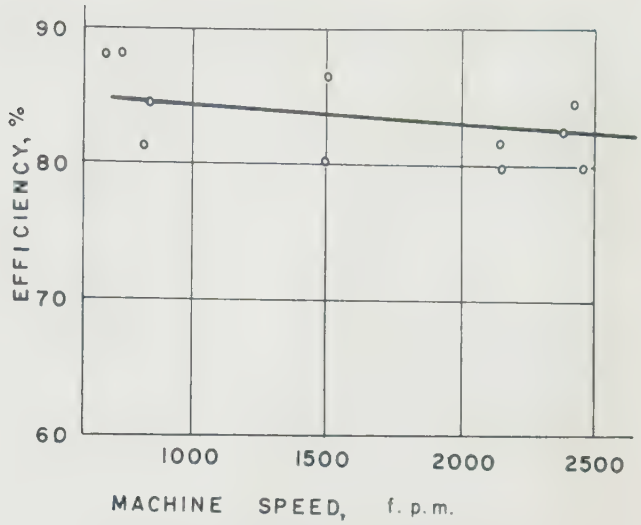

Fig. 4. Machine efficiency versus machine speed for machines under 122 in. wide

which has been available does not, however, give were not successful. In the use of utilities, it is encouraging to note that machine *E*, the latest one, seems to have the most satisfactory performance closely followed by *C*.

Several factors are significant in trying to understand this cost situation. Efficiency, speed, and trim, as well as certain design features, are important starting points in analyzing machine performance. For the moment, only the first two are considered.

Efficiency, while not a cost figure in itself, has a direct effect on costs. Any clues to efficiency trends in various machines are interesting and several significant patterns apparently appear. First, efficiency is related to speed. Figure 3 shows the relationship between efficiency and speed for a series of machines *over* 122 in. wide. It becomes evident that the efficiency drop must be due to the increasing number of breaks and the greater production loss in handling them or both.

Trim width also can be related to efficiency. Figure 4 shows a plot of efficiency versus speed for a series of machines *under* 122 in. wide. Here it will be noted that the machine efficiency is less affected by speed and does not show the sudden downward trend at higher speeds. This would seem to indicate that there are fewer breaks or that the breaks can be handled on machines less than 122 in. wide with greater dispatch and less lost time than those on the wider machines. It would also tend to indicate that the situations leading to breaks and lost time are minimized in the narrower width.

A statistical study of the probability of wire damage, felt damage, breaks, and lost time in general should be rewarding. For instance, the chances of accidental damage to a larger fourdrinier wire should be considerably greater as would be the replacement costs. This probability, which would almost certainly lead to lower operating efficiency, would have to be compared with other operating economies possible in larger machines.

GENERAL DISCUSSION OF PAPER MACHINE DESIGN FEATURES

The discussion of design features given here cannot be supported by a great deal of data. The information answers which are entirely in accordance with many familiar opinions. It is hoped that this analysis will provoke a more detailed examination of our technical-economics concepts.

It seems that many design features or operating conditions have become symbolic of "progress" in the paper industry without careful examination of the cost implications which accompany them. In general, the trend in recent years has been to wider, faster machines using suction presses and more refined types of drying apparatus. Some of the "improvements" have been promoted and accepted during a period when the industry was "oversold." In a seller's market, it was only natural that every effort be expended to increase the production of existing machines. This could, in general, be done by using heat, steam, and power lavishly in the paper machine, and forcing those sections of the equipment which could be pushed on the greater production levels. With a well-balanced design, the areas where increased production could be forced were the fourdrinier where heated water would improve drainage properties and the press section where the use of hot shower water, increased vacuum, and possibly the addition of a press or two would permit some speed increase. Naturally, pressures in drier sections were increased to the maximum workable level to achieve higher drying rates.

When specifying new machines, it was natural to attempt to build into them features which would have been desirable for forcing the older machines. In many cases, these latent desires apparently gave rise to design specifications which were neither balanced or economical to operate. It would be worth pointing out that there is not necessarily any similarity between the methods of forcing more production out of an existing machine and the design specifications for an entirely new piece of equipment.

COST-TECHNOLOGY RELATIONSHIPS

In every process, there is usually one function which becomes a "bottleneck" for the entire operation. Any process can be considered as a series of operations going on simultaneously, each of which has a different speed-cost or speed-efficiency characteristic. As speeds go up, some processes or elements of the operation

Table III. Hypothetical Machines

	Machine					
	X	*Y*	*U*		*V*	
Reel speed, f.p.m.	1,710	1,789	1,920	1,920	1,920	1,920
Efficiency, %	73	76	85	85	80	85
Trim, in.	138	138	96	96	96	96
Production						
Tons/day	30.2	32.6	27.0	27.0	25.4	27.0
Tons/year	10,570	11,400	9,450	9,450	8,870	9,450
Capital cost (less services), MM[a]	3.5	3.5	1.4	1.1	2.1	2.1
			Dollars			
Depreciation/year	175,000	175,000	70,000	55,000	105,000	105,000
Depreciation/ton	16.50	15.34	7.41	5.72	11.83	11.10
Operating cost/year	234,000	240,545	163,750	163,750	136,750	136,750
Operating cost/ton	22.10	21.10	17.33	17.33	15.42	14.47
Total operating cost and depreciation/ton	38.60	36.44	24.74	23.05	27.25	25.57
Savings, % of cost/ton		Base	32	37	25	30

47% capital cost = 9.7% saving/ton
5% efficiency = 6.3 saving/ton

[a] MM = millions.

become more heavily loaded than others, or are, in effect, speed bottlenecks limiting possible increases. There is also a transfer of load from one component to another. Drying load, for instance, is shifted from the press to the drier section as speed increases. Increased production above a certain optimum level is achieved by "forcing" some of the process elements. Although production may go up, there is a general result that efficiency will go down, and that there will be a larger expenditure for utilities per unit production. There are conditions under which this can be justified. Each change or possible alternate process can be examined from an overall cost and productivity standpoint. With this type of analysis it soom becomes evident that when a wide range of possible components are examined, there are both upper and lower limits of speed, width, complexity, etc., beyond which costs rise rapidly.

Another approach is, of course, to eliminate some of these operational bottlenecks by developing improvements in technology. This is the direct responsibility of the R&D group working cooperatively with the engineering and production personnel in the mills. It is also, I believe, a safe course to pursue if the cost implications of the new technology are considered. Where new ideas are pursued without regard to cost (especially on new machines), it is possible to end up with a "solid gold cadillac."

ECONOMIC ANALYSIS AS A DESIGN TOOL

Using the detailed horizontal cross-section of a number of machines making the same or similar product, it is possible to pick out, on the basis of the cost figures, those operations which appear to give the lowest cost increments. It is necessary, of course, to examine this selection of operations to see if they are compatible in the process and to insure that the operating efficiency will be satisfactory.

It might be well to digress for a moment and offer the theory that each operation also has an "efficiency rating" inherent in its technology. The overall process efficiency is the *product* of all the individual efficiencies. The results of one low efficiency rating will be reflected strongly in the overall operating efficiency. Every effort should be made to eliminate or improve low efficiency operations.

An example is given again making use of fictional but realistic data. Table III is a cost comparison of three similar machines, *X*, *Y*, and *U*, together with a hypothetical *V* machine constructed from operations have desirable cost characteristics. These operations were synthesized into a proposed new design. Two alternates of the proposed design were carried out. One assuming a higher operating efficiency and another assuming a lower first cost. It is interesting to note a 5% increase in operating efficiency would more than offset a 30% increase in first cost. Machine, *Y*, a "stock" design, was used as a "base."

In order to check and firm up the new design, it would be necessary to construct a fairly detailed operating budget at the same time the mechanical design is going ahead. No mechanical features should be accepted which are not known to be operable and having a good efficiency factor. Final selection of each feature should be based on the cost pattern and estimate of expected operating efficiency.

It might be well to point out that where machines are designed ignoring the limitations of present day technology and anticipating future improvements, there is a tendency to drastically overbuild the equipment. This trend is so common that one hears relatively little discussion about the first costs of machines and their operating effectiveness from a cost standpoint. It seems to be taken for granted, in recent years, that each succeeding machine a company buys will be wider and designed to operate at speeds for which no technology now exists.

Another type of horizontal cross-section, which is often useful in evaluating alternates in equipment of technology, is shown in Table IV. The basic figure is one of dollar sales/dollar investment. Obviously this figure is of fundamental importance in making business judgments. The data used are for the purposes of illustration only.

WIDTH-COST RELATIONSHIPS

Figures 3 and 4 would appear to indicate that there is a definite relationship between machine width and machine efficiency as operating speeds increase. From these data, it appears desirable, from an efficiency standpoint, to build slow wide machines or relatively fast narrow ones. This brings up the subject of relative cost of wide and narrow machines. It is quite usual for machine builders to state (and even assume) that

Table IV. Dollar Sales/Dollar Investment Summary

Machine number	*Product*	*Speed, f.p.m.*	*Rated tons/day*	*Gross sales/yr.*	*Investment, dollars*	*Sales/ invest, dollars*
1	A	1000	63	5,760,000	3,500,000	1.64
2	A	1300	53	4,610,000	2,100,000	2.20
2	B	1300	38	4,420,000	2,100,000	2.10
2	C	1300	38	5,670,000	2,100,000	2.70
3	A	1300	53	4,610,000	951,000	4.85
3	B	1300	38	4,420,000	951,000	4.65
3	C	1300	38	5,670,000	951,000	5.95

Dollar investment = market value of the installation from pulper to reel, including building and all auxiliaries.

increasing the width of a machine by 40% will not increase the first cost by an equal amount. This opinion was examined in more detail by constructing a horizontal cross-section for a series of components in two machines from the same builder, erected within a short time, and to the same general specifications. Table V is a summary of this investigation. In general, a width ratio of 1.45 produced a cost ratio of 1.68 for the particular items selected. These items were those easily identified and priced. The overall cost ratio was 2.05 from the entire machine. Hence it would seem that the cost of a paper machine increases as the 1.9th power of the width in this width range. It should be emphasized that the above data are not definitive, but do illustrate a technique for examining some important economic facts. It also appears that the cost of buildings and facilities go up rapidly with increased width.

This phenomenon was explained probably when it was realized that wider machines require larger diameter rolls, heavier bearings (which are usually specially built), larger erecting space and equipment, and larger foundry and machine shop equipment. It is also true that the number of potential suppliers decrease as the component sizes go up.

OPERATING SPEED–COST RELATIONSHIP

There are some good reasons for believing that each machine has a speed, less than its maximum, at which it will produce at the lowest cost. Increasing the speed above this optimum will increase the unit cost; however, this may be justifiable under some circumstances. A diagram is used to illustrate some of the important relationships and clarify thinking and terminology. Figure 5 shows the approximate relationship between total operating cost per day of a machine and production in tons per day. Both scales are of a percentage nature. The general shape of the curve was estimated. The actual cost production relationship for one or more paper machines would be extremely useful. For the purpose of this discussion it is only necessary that the general trend be as shown. It should be possible to construct such a curve using a series of horizontal cross sections for the same machine operating at different speeds. The *L*-intercept of the curve *ACB* represents those fixed costs involved in having a machine ready to operate. These include fixed charges, overhead, and an operating crew ready to go to work. As the production rate increases from zero, the total cost of operating begins to increase at a linear rate. The costs which increase as production increases include utilites, supplies, and maintenance parts and auxiliary labor. The increase in total operating costs per day curves upward as the design capacity is approached and becomes very steep at

Table V. Cost of Machine Components for Similar Two Machines of Different Widths

	Machine X	*Machine* Y	Y/X
	Dollar × Coding Factor		
Width, in.	142	206	1.45
Fourdrinier frames, save-all misc.	90,000	130,000	1.45
Dandy rolls	8,800	18,800	2.14
Table roll deflectors	6,500	10,000	1.54
(3) R.C. wire rolls	3,300	7,270	2.19
Doctors	9,000	8,000	.89
Bottom couch roll	9,500	16,300	1.72
Press & Yankee framework	51,327	113,168	2.20
(2) 28-in. R.C. top press rolls	16,860	23,486	1.40
(2) Automatic & hand guides	2,400	2,800	1.16
Felt suction box	2,150	2,050	0.955
Guard board	1,500	2,350	1.53
Suction press roll (bronze)	30,500 (28 in.)	65,634 (41¾ in.)	2.15
After drier parts			
(7) 60 in. driers	30,000	52,800	1.76
Frames & end gears	34,220	34,500	1.01
Steam fits	2,400	2,400	1.00
Drier felt equipment	24,000	47,080	1.96
Mount Hope roll	3,680	4,500	1.22
Calender	22,000	48,000	2.18
Reel	35,000	58,000	1.66
Foundation plates	15,000	21,000	1.40
Total for parts listed	398,279	668,294	1.68
Machine total	637,397	1,304,925	2.05
Spare parts	79,527	241,007	3.03

higher production rates. Extremely high costs will be found for maximum possible production rates due to the overriding effect of low efficiency encountered at near maximum speeds. Although this information is representative for most machines, the analysis given below is dependent only upon the upward trend of the

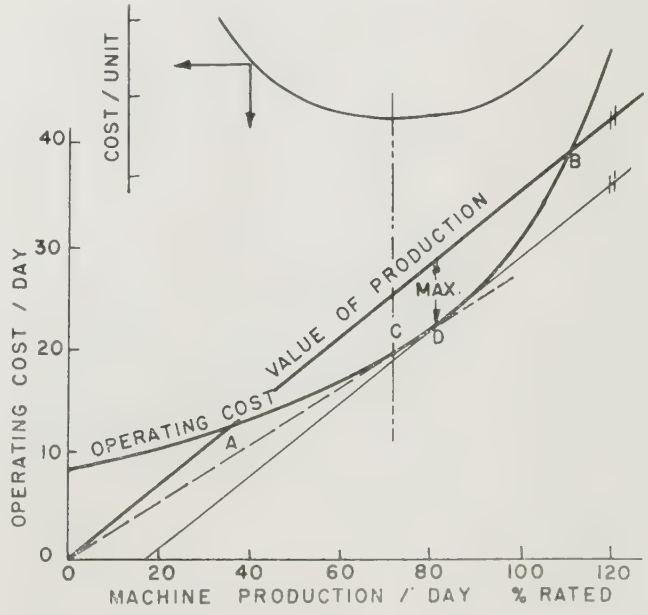

Fig. 5. Operating cost–machine production relationships

cost curve which has been found to hold for all commercial machines. A second line starting from the origin shows the value of the product. This increases linearly with the production rate as given along the horizontal scale. If this is a profitable operation, the line showing the value of the product will intercept the total-cost curve at points A and B. Between A and B, where the value of the product is greater than the cost, the vertical distance between the two curves represents the profit produced by the machine.

If the value of the production curve just touches the cost curve, we have a "breakeven" value of the product as shown by the tangent OC. The slope of this line represents the lowest possible value of goods the machine can produce and break even. Another way of arriving at this same point is to divide the total cost of operation at any given production rate by the number of units produced, thus giving the production cost per unit. This is plotted in Fig. 5 and it will be noted that the minimum production cost per unit occurs at the same production rate as that of point C.

It is wrong to assume, however, that the *maximum profit* will be made when the goods are produced at the *lowest cost per unit*. There is a bias or factor which favors increased production. We are not, in effect interested in profit per unit but in the profit per unit *times* the total production. This is illustrated in Fig. 5 by point D, which is located at the point of maximum distance between the curve of costs and value of goods produced. The difference, between the point where maximum profit is made and the lowest production cost is realized, depends upon the value of the product. Thus, if the value of the product is reduced to the breakeven value, C and D will coincide. As the value of the product per unit increases, the maximum profit occurs at higher and higher production rates. Knowing the production costs versus capacity for a given machine, it would be possible to determine the most desirable operating point. Low profit grades could be produced at the proper capacity to realize the maximum profit. High profit grades should be produced at an increased production rate where again maximum profit would be realized. This appears to be in direct contrast to the operating philosophy of many mills and should provide an interesting field for further study.

It is hoped that the hypothetical examples given and tentative conclusions reached in this discussion will serve to illustrate the techniques proposed without obscuring the real purpose of their use. This purpose is to stimulate interest in and demonstrate that technical economics is a powerful tool for decision-making.

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Air Impingement Drying

Evaporation from Thin Web on a Paper Machine Cylinder with Forced Convection

CLAËS ALLANDER

The paper treats the basic physical processes connected with the evaporation from a sheet on which air is impinged when the sheet runs over a heated cylinder. The equations for the heat and mass flow are presented and their solutions are given in the form of curves. The following assumptions are made: The sheet is wet and in good thermal contact with the cylinder; variations in degree of moisture in the sheet does not influence evaporation; the cylinder is either so large, or runs at such a slow speed, that the heat-up period of the sheet is short compared to the total time of the sheet on the cylinder. From the partial derivatives of an approximate equation conclusions are drawn concerning the factors one should alter to reach maximum evaporation rate under given conditions. It is mainly the heat transfer coefficient, h_{01}, at the surface of the sheet that influences the effectiveness of a hood whereby the power consumption is the limiting factor. Tests have been made to determine the best values of different factors for optimum h_{01} for a given air supply power. The results of the tests are presented in the form of curves and summarized by an equation giving h_{01} as a function of the air supply power, the hole diameter, and the distance between the perforated plate and the cylinder for a plate perforation of 1.5–3.5%.

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THE evaporation rate on a paper drier is influenced by a number of different factors such as: steam pressure in the drier, cylinder shell thickness and conductivity, paper grade, condition of the air outside the sheet and the heat transfer coefficient between the air and the sheet. Developments toward higher evaporation rates have been dominated, during the past decade, by a determined effort to affect the latter two factors. Thus it has been possible to obtain considerable production increases by means of suitably designed air impingement systems especially on machines producing lightweight paper such as Yankee driers.

This paper presents a method for evaluating the effect on evaporation by the more significant factors, and also discusses various air impingement patterns. In the interest of clarity the investigation is limited to apply to a thin sheet being dried within the constant-rate zone, i.e., to 70 to 80% dryness. This means that the paper is so thin that the influence of vapor diffusion and moisture migration within the sheet can be neglected. The sheet is further assumed to be in good thermal contact with the cylinder so that the interface heat transfer coefficient is large. In other words, the paper is considered as a liquid film with regard

given to the temperature gradient across the thickness but not to any possible moisture gradient.

The process is further considered as stationary, which means that the heatup period of the sheet is assumed small compared to the evaporation period. This is no doubt justified for Yankee cylinders where the complete drying cycle takes place on one single cylinder over a comparatively long interval. However, the smaller and faster the cylinder is the more influential becomes the heatup period. The results should therefore be considered significant for large-diameter driers and valid, with some reservation, for ordinary paper driers at high speeds.

NOMENCLATURE

ϑ_0 = temperature of impinging air, °F.
ϑ_1 = temperature of outside paper surface, °F.
ϑ_2 = temperature of closed paper surface, °F.
ϑ_3 = temperature of outside cylinder surface, °F.
ϑ_4 = temperature of inside cylinder surface, °F.
ϑ_5 = temperature of steam inside cylinder, °F.
ϑ_m = proportional mean temperature, °F.
ϑ_s = dew point temperature of impinging air, °F.
h_{01} = heat transfer coefficient between impinging air and paper, B.t.u./(sq. ft.) (hr.) (°F.)
h_{23} = heat transfer coefficient between paper and cylinder, B.t.u./(sq. ft.) (hr.) (°F.)
h_{45} = heat transfer coefficient between steam and cylinder, B.t.u./(sq. ft.) (hr.) (°F.)
k_{12} = heat conductivity of paper, B.t.u./(ft.) (hr.) (°F.)
k_{34} = heat conductivity of cylinder, B.t.u./(ft.) (hr.) (°F.)
s_{12} = thickness of paper, ft.
s_{34} = thickness of cylinder, ft.
U = overall heat transfer coefficient between steam and outside paper surface, B.t.u./(sq. ft.) (hr.) (°F.)
g = specific evaporation intensity, lb./(sq. ft.) (hr.)
r = latent heat of evaporation, B.t.u./lb.
p_s = partial pressure at saturation of water vapor at temperature of outside paper surface, lb./sq. ft.
p_0 = partial pressure of water vapor in impinging air, lb./sq. ft., or in. Hg.
p_a = partial pressure of air, lb./sq. ft.
k_{c01} = mass transfer coefficient, ft./hr.
R_w = gas constant for water vapor, ft./°F.
T_1 = absolute temperature of paper surface, °R.
ρ_a = density of air, lb./cu. ft.
c_p = specific heat of air at constant pressure, B.t.u./(lb.) (°F.)
κ = proportionality constant
v = velocity of impinging air jets, ft./min.
N = specific power expenditure over perforated plate of impinging air, hp./sq. ft.
h = heat transfer coefficient between impinging air and a smooth surface, B.t.u./(sq. ft.) (hr.) (°F.)
N_{Nu} = Nusselts number
N_{Re} = Reynolds number
d = diameter of holes in perforated plate, in.
H = perforated plate distance, in.
μ = perforation percentage

MAIN EQUATIONS

Figure 1 gives the factors which primarily affect the evaporation under the given premises. For stationary and radial heat flow the following equations for its intensity are obtained:

$$h_{45}(\vartheta_5 - \vartheta_4) = \frac{k_{34}}{s_{34}}(\vartheta_4 - \vartheta_3) = h_{23}(\vartheta_3 - \vartheta_2) = \frac{k_{12}}{s_{12}}(\vartheta_2 - \vartheta_1) = gr + h_{01}(\vartheta_1 - \vartheta_0) \quad (1)$$

It is suitable to introduce the "overall" coefficient of heat transfer of the cylinder and the paper, i.e., from steam to exposed paper surface, defined as:

$$\frac{1}{U} = \frac{1}{h_{45}} + \frac{s_{34}}{k_{34}} + \frac{1}{h_{23}} + \frac{s_{12}}{k_{12}} \quad (2)$$

and the equations for heat flow intensity transform into:

$$U(\vartheta_5 - \vartheta_1) = gr + h_{01}(\vartheta_1 - \vartheta_0) \quad (3)$$

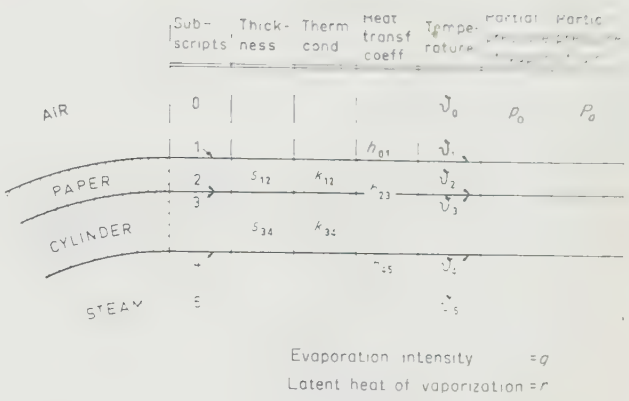

Fig. 1. Factors on which evaporation depends

All components except g and ϑ_1 are here considered as known. Thus one addition equation is required for the solution and this is of course the equation for vapor diffusion through the boundary layer outside the paper.

The transport of the evaporated water g from the paper surface is subject to the following relation provided the partial pressure difference is not too big:

$$g = \frac{k_{c01}}{R_w T_1}\{p_s(\vartheta_1) - p_0\} \quad (4)$$

The relation between the mass transfer coefficient and the heat transfer coefficient is obtained by a comparison of the analogies between diffusion and heat transfer. In this manner a modified form of Lewis's Law is obtained, namely:

$$k_{c01} = \kappa \frac{h_{01}}{\rho_a c_p} \quad (5)$$

where ρ_a is the density of the air and c_p its specific heat. The coefficient κ is dependent on the type of flow and the condition of the air. A value of $\kappa = 1$ is often used.

Calculated with $\kappa = 1$ and using the laws for ideal gases, equation (4) can be transformed to the approximate equation:

$$\frac{g}{h_{01}} \cong \frac{0.62}{c_p} \cdot \frac{p_0}{p_a} \cdot \left\{\frac{p_s(\vartheta_1)}{p_0} - 1\right\} \quad (6)$$

By expressing the "proportional" mean temperature ϑ_m according to the relation:

$$\vartheta_m = \frac{U\vartheta_5 + h_{01}\vartheta_0}{U + h_{01}} \quad (7)$$

equation (3) can be rewritten as:

$$\vartheta_m = \vartheta_1 + r \cdot \frac{h_{01}}{U + h_{01}} \cdot \frac{g}{h_{01}} \quad (8)$$

RESULTS OF CALCULATIONS

Equations (6) and (8) facilitate calculations of the factor g/h_{01} as a function of ϑ_m for various values of $h_{01}/U + h_{01})$ and p_0. The vapor saturation curve is, of course, utilized for these calculations. The result will be a diagram of the type shown in Figs. 2 to 5. It can be seen that for larger values of ϑ_m the partial pressure of the vapor in the air does not influence the evaporation rate to any appreciable extent. This in turn means that reasonable deviations from Lewis's Law, that is reasonable errors in equation (6) will not

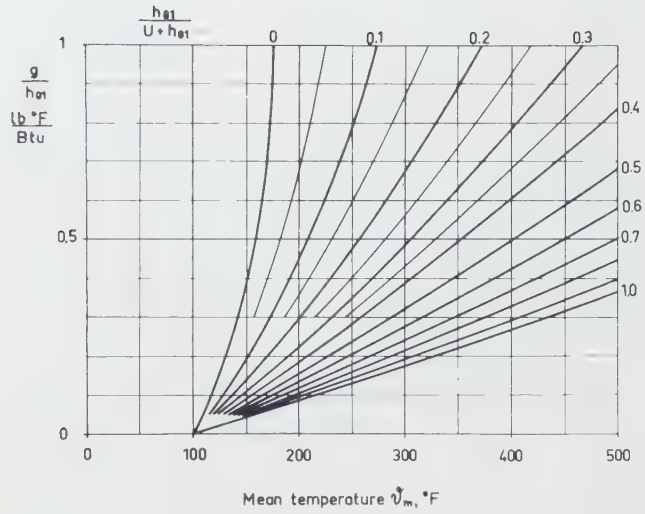

Fig. 2. Evaporation rate curves for partial pressure of the vapor in the air, p_0 = 2 in. Hg

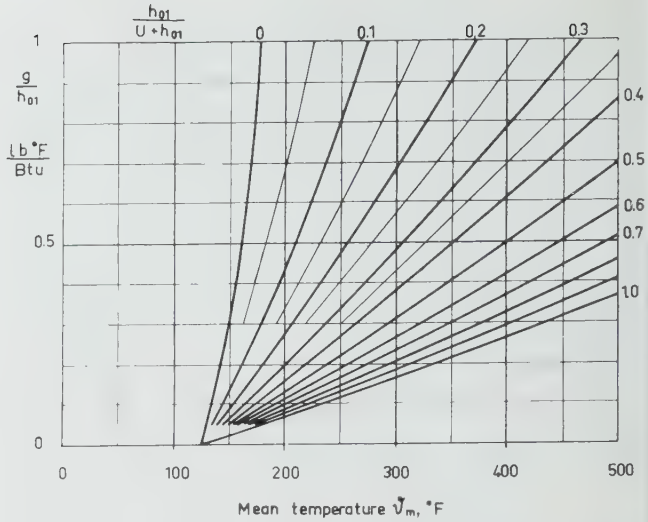

Fig. 4. Evaporation rate curves for partial pressure of the vapor in the air, p_0 = 8 in. Hg

normally mean decisive errors in the final result. Chosing, for instance, $p_0 = 4$ in. Hg $\vartheta_m = 330$°F. and $h_{01}/(U + h_{01}) = 0.2$, this will give $g/h_{01} = 0.8$. Should the factor 0.62 in equation (6) be increased by 40%, that is, to 0.87 with the other values remaining unchanged, this will give, $g/h_{01} = 0.84$. In other words, only a 5% change occurs in the result. The reason is, of course, the steepness of the curve for the partial pressure of vapor at saturation.

Figure 4 shows the evaporation for impingement with pure steam. Because the evaporation vapor in this instance no longer diffuses into air the value of the constant 0.62 in equation (6) will be changed. An estimate of the diffusion coefficient based on the molecular weights will, instead, give a value of 1.8. This will, however, hardly affect the end result because of the large value of ϑ_1 and the related great steepness of the vapor saturation curve.

A significant factor with regard to the paper quality is its surface temperature ϑ_1. This temperature can easily be calculated from equation (8), rewritten as:

$$\vartheta_1 = \vartheta_m - r \cdot \frac{h_{01}}{U + h_{01}} \cdot \frac{g}{h_{01}} \qquad (9)$$

It may be of interest to note the increase in surface temperature resulting from the use of steam as impinging medium. For a well-designed hood working with $p_0 = 8$ in. Hg a value of $g/h_{01} = 0.7$ is not at all unreasonable when the mean temperature is 315°F. and $h_{01}/(U + h_{01}) = 0.2$. The corresponding surface temperature will be 179°F. A corresponding evaporation rate for the same value of $h_{01}/(U + h_{01})$ when using steam as impingement medium will however require a "mean temperature " ϑ_m as high as 360°F., which gives a surface temperature of 222°F. This can result in difficulties, with the paper separating from the cylinder as the vapor saturation pressure between paper and cylinder will be substantially higher than the atmospheric pressure.

APPROXIMATE EQUATIONS

At a partial pressure above 4 in. Hg of the vapor in the impingement air, it is apparent that a linear approximation can be made of the relation between g/h_{01} and ϑ_m. As it is desirable, for reasons of heat economy, to work above this limit, the conclusions drawn from the approximated equations will have practical validity. The approximate equation will appear as follows:

$$\frac{g}{h_{01}} \cong \frac{1}{r} \cdot \frac{\vartheta_m - \vartheta_s}{[h_{01}/(U + h_{01})] + \epsilon} \qquad (10)$$

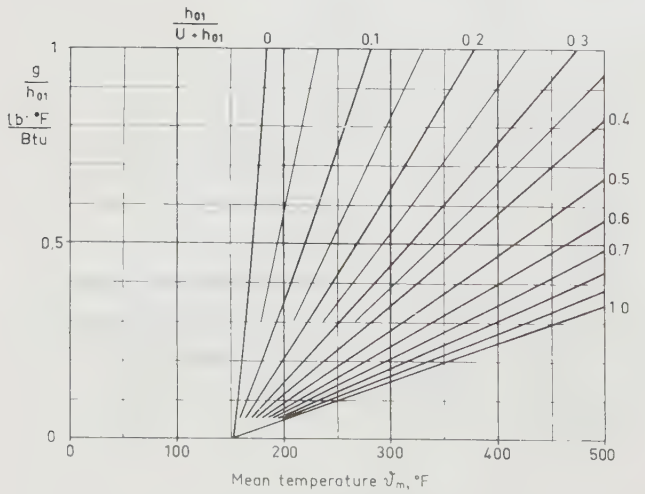

Fig. 3. Evaporation rate curves for partial pressure of the vapor in the air, p_0 = 4 in. Hg

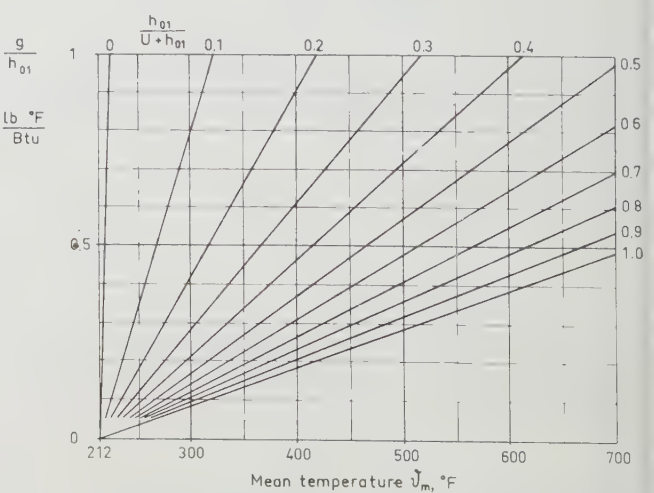

Fig. 5. Evaporation rate curves for partial pressure of the vapor in the air, p_0 = 30 in. Hg

where ϑ_s is the dew point temperature and ϵ is a correction term. The accuracy of the approximation improved with increasing ϑ_s. If the function for ϑ_m is introduced into equation (10) and the partial derivatives with regard to ϑ_5 and ϑ_0 are formed, this will give:

$$\frac{\partial g}{\partial \vartheta_5} \cong \frac{U}{r\{1 + \epsilon[U + h_{01})/h_{01}]\}}$$
$$\frac{\partial g}{\partial \vartheta_0} \cong \frac{h_{01}}{r\{1 + \epsilon[(U + h_{01})/h_{01}]\}} \qquad (11)$$

It can be seen that if U is larger than h_{01}, it is better to increase ϑ_5 rather than ϑ_0. Since U for normal cylinders is higher than 60 B.t.u. per (sq. ft.) (hr.) (°F.) it can be stated with certain general validity that an increase of the temperature ϑ_5 will give a greater production increase than a corresponding increase of the impingement air temperature.

Fully analogous conclusions can be drawn for the variation of g with regard to U and h_{01} when the temperatures are constant. We will thus obtain the corresponding approximate derivatives:

$$\frac{\partial g}{\partial h_{01}} \cong \frac{\vartheta_0 - \vartheta_s}{r\{1 + \epsilon[(U + h_{01})/h_{01}]\}}$$
$$\frac{\partial g}{\partial U} \cong \frac{\vartheta_5 - \vartheta_s}{r\{1 + \epsilon[U + h_{01})/h_{01}]\}} \qquad (12)$$

In the derivation the influence of the ϵ-product in the denominator has been neglected. Equation (12) shows that when ϑ_5 is higher than ϑ_0 it is better to increase U rather than h_{01} and vice versa.

To the machine builders it can be of interest to notice that the product $U(\vartheta_5 - \vartheta_s)$ shall be as high as possible. This is directly apparent from equation (10) when the expression of ϑ_m is inserted. Since a high U-value requires a thin cylinder shell, and a high ϑ_5 value a thick cylinder, this becomes a problem of optimization.

THE HEAT TRANSFER COEFFICIENT h_{01}

The equations and figures show that for a given cylinder h_{01} and ϑ_0 are the external factors which can essentially affect the evaporation rate. The temperature ϑ_0 is determined by the available heating source and is more or less independent of the design of the hood. Thus, it is mainly through the heat transfer coefficient h_{01} by which the designers can affect a hood. It is essential to obtain the highest possible value of h_{01} whereby the power consumption is the limiting factor.

A high heat transfer coefficient requires high impingement velocities, which means that relatively large air quantities are set in motion. To avoid unnecessary losses in duct work, modern so-called "efficiency" hoods are often made with circulation fans directly connected to the hood. This also gives the advantage of a compact design. The following discussion assumes that the external pressure losses are reduced to a minimum and thus the major question will be:

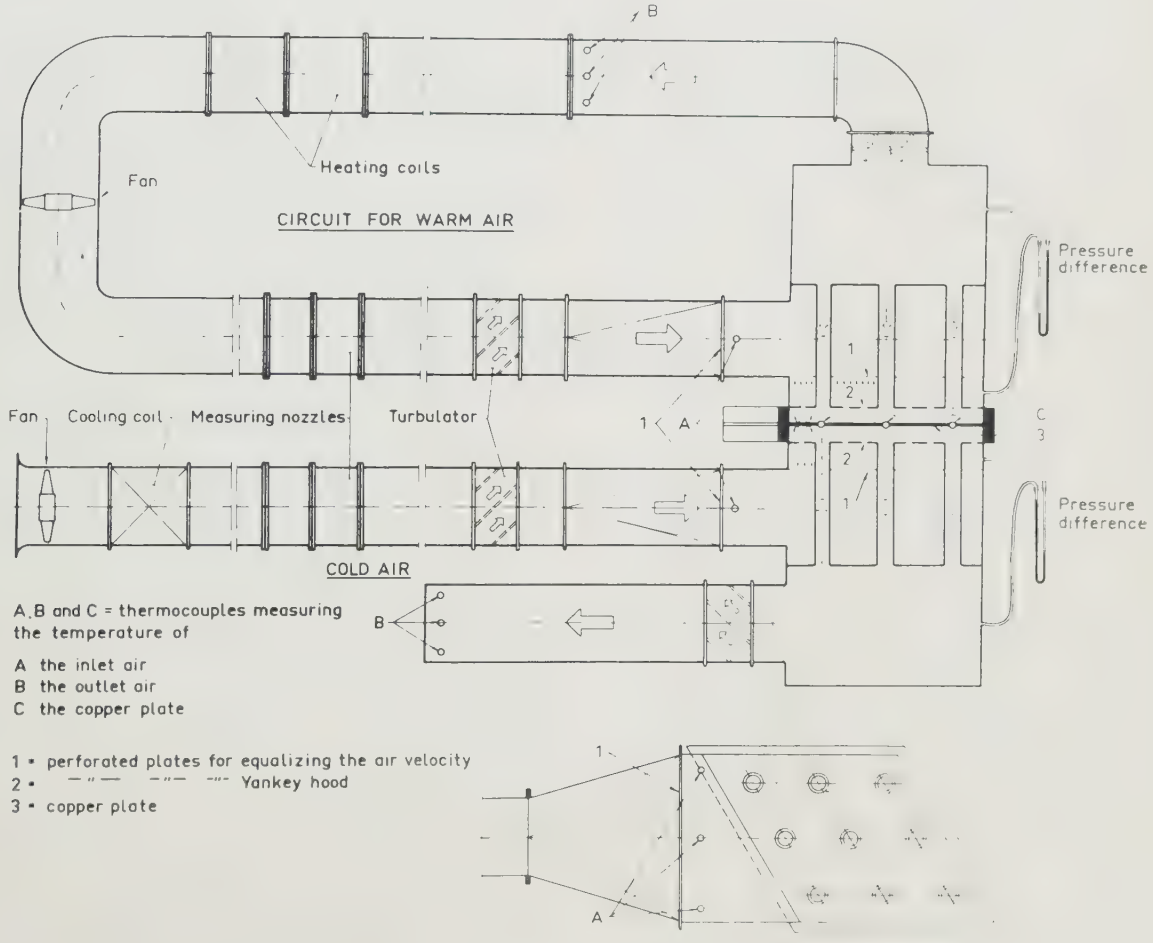

Fig. 6. Test apparatus

How does the heat transfer coefficient h_{01} vary with the power consumption, and how shall the impingement system be arranged to obtain highest possible ratio of h_{01} per kw. afforded to the system?

The following section will attempt to answer these two questions.

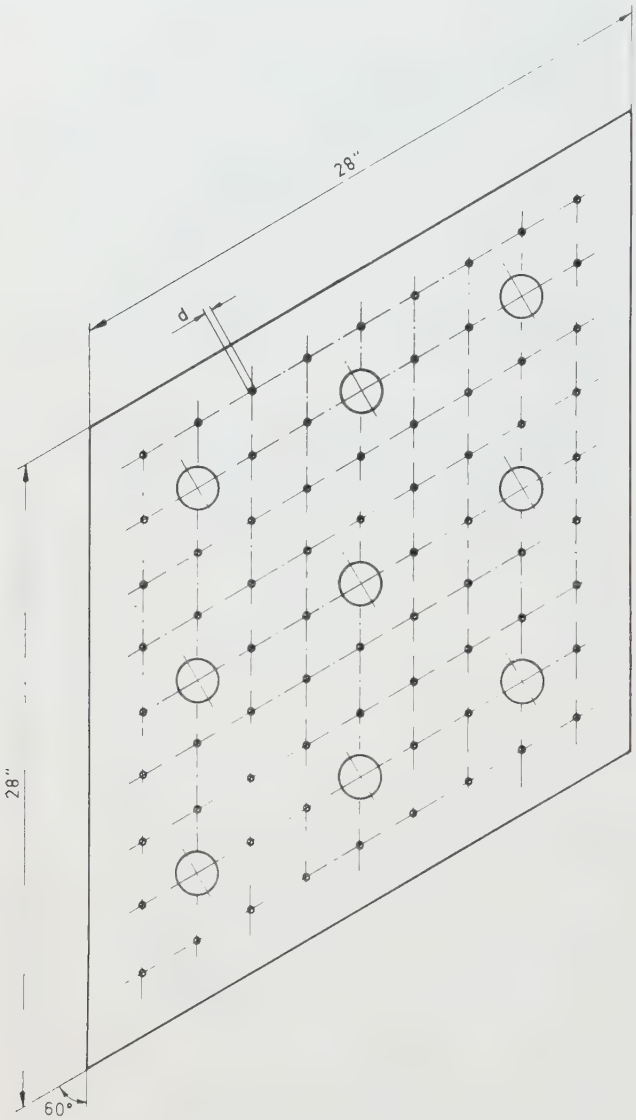

Fig. 7. Perforated plate used in the tests

The heat transfer coefficient for a given impingement, h_{01}, can be expressed as a potential relation:

$$h_{01} \sim v^n \qquad (13)$$

where v is a representative air velocity. The proportionality constant and the exponent depends on the geometrical pattern of the impingement system. The transported air quantity is proportional to v and its pressure drop to v^2. Thus the power consumption will be:

$$N \sim v^3 \qquad (14)$$

Elimination of v between these two equations gives:

$$h_{01} \sim N^{n/3} \qquad (15)$$

The earlier discussion showed a linear relation between heat transfer and evaporation. This means that for higher heat transfer coefficients g will increase linearly with $N^{n/3}$. Considering that the exponent n for all known impingement patterns is between 0.5 and 0.8 it is realized that the possibilities to increase evaporation rates with higher power expenditure are sharply limited. The major issue is therefore to select the impingement pattern so that the proportionality constant becomes as high as possible.

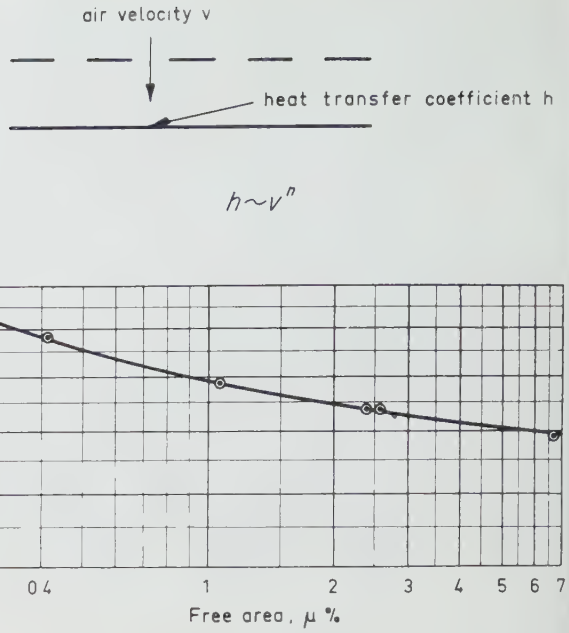

Fig. 8. The dependence of the exponent n upon the perforation percentage

According to our investigations the most favorable heat transfer values are obtained if the air stream impingement on the cylinder is made up of a large number of air jets. These jets can be produced as is usually done, by blowing the air through a perforated plate at a suitable distance from the cylinder surface. The air after impinging on the cylinder can then be led away through an array of exhaust slots or exhaust holes. The hoods made by Svenska Flaktfabriken use the latter type of exhaust because it seems to give a better air flow and it allows a stronger construction.

TESTS TO DETERMINE h_{01}

A series of tests have been carefully performed to find the perforation percentage, hole size, and distance between plate and cylinder for the optimum heat transfer coefficient for a given air supply power. These tests have been made as follows:

Air at temperature of about 60°F. was blown through a perforated plate at constant velocity against a copper plate measuring about 28 by 28 in. The blowing device was constructed basically in the same way as for a normal Yankee cylinder hood and remained unchanged during the whole series of tests. This gave a constant heat transfer coefficient ($h = 35 \pm 1$ B.t.u. per (sq. ft.)(hr.)(°F.) on this side of the plate to serve as a reference value. Warm air at about 120°F. was blown against the other side of the copper plate at varying velocities from a blowing system made so that its various characteristic parameters could be varied.

The temperature differences between the copper

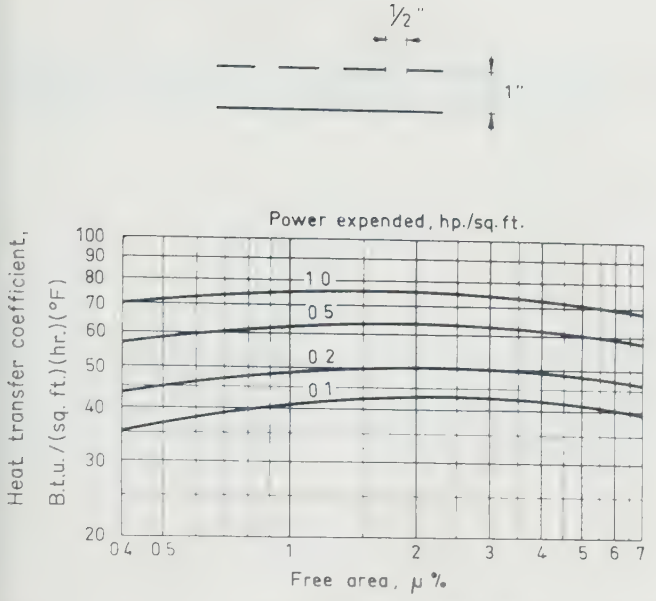

Fig. 9. Heat transfer coefficient at constant values of the expended power vs. perforation percentage

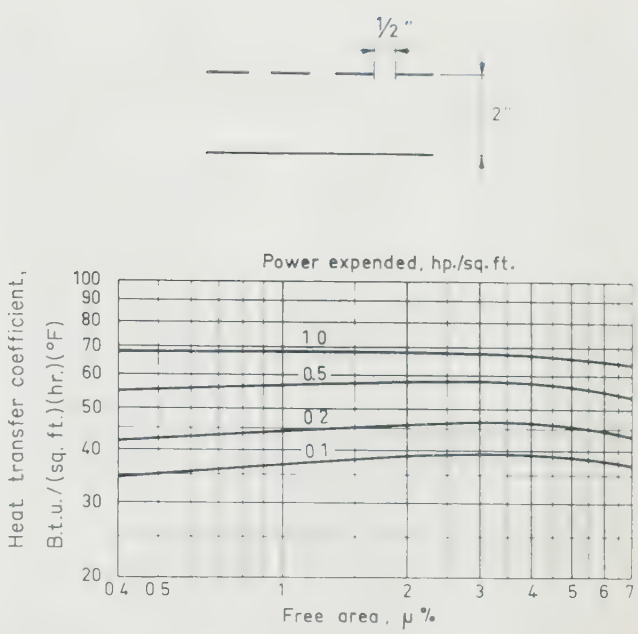

Fig. 10. Heat transfer coefficient at constant values of the expended power vs. perforation percentage

plate and the air on either side were measured with thermocouples at several different points. The temperature of the air was taken at the mean value of the inlet and outlet air temperatures. The two temperature differences give a simple relationship between the heat transfer coefficients for the two sides, i.e.:

$$\frac{h}{h_0} = \frac{\Delta\vartheta_0}{\Delta\vartheta} \qquad (16)$$

where h_0, and ϑ_0 are the values for the reference side and h and $\Delta\vartheta$ are the values for the variable side.

The advantages of this method of measuring are: it is relatively fast and accurate, and heat losses are very small. Other methods that we have tried, for instance, using electrically heated plates, have not given sufficiently accurate results. The principle of the test apparatus is shown in Fig. 6.

It should be observed that the heat transfer coefficient which is thus obtained cannot be used directly as h_{01}. A correction with regard to the structure of the paper surface must be done. In order to avoid confusion between the ideal heat transfer coefficient at a smooth surface and the real one discussed above, we shall, in the following, use the symbol h for the first one. However, it may be presumed that for one and the same paper h and h_{01} are proportional.

The perforated plates used in these tests were basically similar to that shown in Fig. 7. The air is blown through the small holes against the plate and exhausted through the large holes. Tests were made using different sizes of inlet and exhaust holes, different perforation percentages and different distances between the perforated plate and the copper plate. The heat transfer coefficient was determined in each test for different values of the air velocity.
Given the relationship:

$$N_{Nu} \sim N_{Re}^{n} \cdot f(\mu, H/d) \qquad (17)$$

and limiting the evaluation to apply for the air in the temperature range used in these tests, the result can be summarised by the following expression:

$$h \sim N^{n/3} \cdot d^{n-1} \cdot g(\mu, H/d) \qquad (18)$$

where N is the applied air supply, that is, the power required to overcome the air resistance of the perforated plate. This power does not include that required to overcome the resistance in the exhaust system.

RESULTS OF THE TESTS

The exponent n, rather surprisingly, is strongly dependent on the perforation percentage, as is shown in Fig. 8.

Since the hoods of Yankee machines are relatively large they are generally made stationary. The distance between the hood and the cylinder is usually selected between 1 and 2 in. To give heat transfer coefficient values of practical use two diagrams have been based on the test results. These diagrams, Figs. 9 and 10, give the heat transfer coefficient as a function of the perforation percentage with the air supply power as parameter for a hole diameter of 0.5 in. and perforated plate to cylinder distances of 1 and 2 in.

It can be seen that this gives a relatively flat maximum at about 2.5% perforation. Thus with reasonable accuracy, for a perforation of between 1.5 and 3.5% the heat transfer coefficient can be written as a function of the air supply power, the hole diameter and the plate cylinder distance:

$$h = 66 \cdot N^{1/4} \cdot d^{-1/4} \cdot (1 - 0.035\, H/d) \text{ B.t.u. per (sq. ft.) (hr.) (°F.)} \qquad (19)$$

where $2 \leqq H/d \leqq 8$

The air supply power N should be given here in hp. per sq. ft., and the hole diameter in inches.

At boundary layer temperatures differing considerably from those used in these tests it is necessary to apply corrections for changes in the physical constants of the air. With the exponent n known this can be done without difficulty.

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The Tear Strength of Emulsion Polymer-Impregnated Paper

Effect of Rate of Testing

PAUL J. McLAUGHLIN

Initial and internal tearing resistance of papers impregnated with thermoplastic polymer are quite sensitive to polymer composition. For a series of saturants of similar molecular size and functional-group content, it has been shown earlier that increase in polymer hardness (within limits) produces increase in tensile strength accompanied by decrease in edge tear strength. It has now been found that edge or internal (trapezoid) tear strength for a given polymeric saturant is sensitive to rate of testing (jaw separation). In nearly all cases, a maximum value is observed at some rate and this optimum rate as well as the measured strength are strongly affected by polymer composition, hardness, molecular size, and nature of the emulsifier used during synthesis. Reduction in molecular size raises tear strength over much of the range of rates and shifts maximum to higher rates. At constant molecular size, progressive reduction in functionality causes progressive increase in tear strength and optimum rate of jaw separation. The results can be interpreted in terms of polymer cohesive strength, interfiber bonding strength, and adhesion of polymer to fibers.

THE EXACT requirements of the applications for polymer-impregnated papers are seldom known to the supplier of synthetic polymers in any substantial detail. In order to determine the suitability of a saturant it is usually necessary to rely on measurement of properties expected to be relevant to the final use. Among these are: wet and dry tensile strengths, elongation, toughness, and (increasingly, as the range of usefulness of saturated papers broadens) stability to heat, ultraviolet light, and solvents. Attempts have been made to relate some of these properties to polymer composition. For example, the effects of polymer hardness and functional group content on tensile and edge-tear strengths have been measured by Sweeney (*1*) for acrylic ester emulsion polymers.

The effects sought by use of thermoplastic polymers as saturants are distinct from power or fiber substitution values realized when certain water-soluble polymers are added internally at low levels, as described by Davison, Putnam, Mashburn, and Ware (*2*). They are more nearly related to the "property-disproportionation values" defined by these authors, but are obtained at substantial levels of addition (20 to 100% expressed on fiber). In general, one attempts to modify the effect of natural fiber-fiber bonds by introduction of polymer films which reinforce the matrix, permitting, for example, large increases in post-yield extensibility, as described by Heyse, Sarkanen, and Stannett (*3*) and by McLaughlin (*4*). These special effects are notably time-dependent, especially with the softer saturants (*3*).

It has been found that useful information about the behavior of thermoplastic saturants can be obtained by measurement of edge and internal tearing resistance as a function of rate of testing (jaw separation). The results are of practical value in suggesting the suitability of saturants for various uses. Beyond this, they permit tentative but apparently reliable conclusions about the nature of bonding in polymer-saturated paper.

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EXPERIMENTAL

Preparation of Saturated Papers

The polymer dispersions were used at solids contents of 40 to 46% in almost all of this work, and the pickup adjusted to 77 ± 2% (expressed on fiber) by slight changes in pressure on the rubber squeeze rolls through which the impregnated sheets were passed. Following impregnation, the sheets were dried at 180°F. for 5 min. in a draft oven, then conditioned overnight at 74°F. and 50% R.H.

Base Papers

Three papers were employed, as shown in Table I.

Table I. Base Papers Used in This Study

Paper	*Fiber type*	*Basis weight* — *lb.*[a]	*Basis weight* — *g.s.m.*	*Caliper, mils*	*Fiber freeness, C.S.f., ml.*
1	Bleached kraft	36.8	59.9	5.6	575
2	Bleached kraft	85.0	138.0	11.8	655
3[b]	Dacron bleached sulfite (60:40)	31–36	51–59	9–11	470[c]

[a] 3000 sq. ft., conditioned at 74°F., 50% R.H.
[b] Nondirectional (Noble-Wood) sheets. The Dacron was 3 denier per filament, 1/4 in. length, type 54 (E. I. du Pont de Nemours & Co.). It was added to the beaten wood pulp at the disintegrator without any preliminary treatment.
[c] Bleached sulfite component.

Polymers Used As Saturants

The polymers were standard or experimental dispersions having the compositions shown in Table II. The shear modulus (G) and T_i (inflection temperature) of each polymer were measured as described in earlier publications (*4*, *5*). T_i is defined as the temperature at which G equals 300 kg. per sq. cm., as suggested by Williamson (*6*), and is an approximate measure of hardness. The value of G at 20°C. is also given in Table II.

Test Methods

Edge tear resistance was measured by means of the Finch stirrup described in TAPPI Standard T 470 m-54. The standard value was obtained by that method, using the Scott* IP-4 tester (Table III). Values at various rates were measured by inserting the stirrup in the upper jaw of the Instron tester and using rates of 0.50, 5.0, 10.0, 20.0, and 50.0 in. per min.

* Scott Testers, Inc., Providence 1, R. I.

Table II. Polymeric Saturants of This Study

Polymer	Monomer composition[a]	T_i, °C.	Shear modulus 20°C., kg./cm.²	Functional group		$\bar{M}_v$[b]
				Type	Level, mole %	
A	EA 100	−16	1.4	None	...	1.50×10^6
B	EA 100	−16	1.7	Amide	4.7	1.50
C	EA 100	−13	3.3	Carboxyl	1.9	1.10
D	EA 89, MMA 11	−7	4.0	Carboxyl	1.9	3.24
E[c]	EA 89, MMA 11	−7	3.7	Carboxyl	1.9	0.119
F	EA 90, MMA 10	−6	2.6	Amide	2.3	0.119
G	EA 90, MMA 10	−10	1.9	Amide	1.1	0.119
H	EA 67, MMA 33	+16	160	Amide	4.7	1.50
K	B 66, AN 34	−23	12.0	None	...	...
L	B 66, AN 34	−25	5.8	None	...	...
M	VAc 100	+26	2400	None	...	...

[a] Proportions of principal monomers excluding functional comonomers were present. EA = ethylacrylate, MMA = methyl methacrylate, B = butadiene, S = styrene, AN = acrylonitrile, VAc = vinyl acetate.
[b] Viscosity-average molecular weight from intrinsic viscosities in acetone. Values for amide types were estimated from those for carboxyl-containing polymers produced by similar procedures.
[c] Saturant E[1] was identical with E in all respects, except that synthesis was carried out in presence of an anionic soap (sodium salt of an alkyl ayrl polyether sulfate). E was prepared in presence of a nonionic emulsifier (octylphenol–ethylene oxide condensate).

Trapezoid tear strength was measured at the standard rate, 2.0 in. per min. (ASTM Standards Part 7, Standard No. D39-49, p. 151, 1955) using the Instron tester with integrator and 30 sec. integration. It was also measured at 0.02, 0.10, 0.50, 1.0, 2.0, 10.0, and 20.0 in. per min.

The samples were tested in the cross-direction. (In the case of trapezoid tear, therefore, the initial cut was made in the machine direction.) In a few cases, machine-direction tests were also made.

RESULTS AND DISCUSSION

Variation of Tear Strength with Rate of Jaw Separation (Nonfunctional Polymers)

Polymers of ethyl acrylate and of nonfunctional butadiene-acrylonitrile types were used at the 77% level on fiber (base paper 1) and the trapezoid and edge-tear strengths measured at various rates. Figures 1 and 2 show the results on a semilogarithmic plot. Both properties showed marked dependence on rate. The values of trapezoid tear are numerically much smaller than those for edge tear and undergo a larger percentage change as rate is varied.

The base paper, a typical saturating type, is not very strong; all of the saturants add appreciably to tensile strength and more notably, to elongation at failure. Base paper 1 has a trapezoid tear strength of about 0.40 lb. not appreciably affected by rate, and an edge-tear strength of about 5.5 lb. per in. width, similarly unaffected, except at the highest rate (50.0 in. per min.) where it falls off to 3.9 lb. per in. width.

Nature of Tearing Failure

It is recognized that edge tearing resistance is the moment of force needed to start a tear and that it is determined by the tensile strength and stretch of the paper (*9*). The decrease in edge-tear strength (measured in the standard way) with increasing polymer hardness observed for polymer (acrylic ester) saturants (*1*) must then be due to a loss of elongation more pronounced than the increase in tensile strength.

Similarly, it is known that internal tear strength depends on strength and elongation (*7*, *8*), and Steele and Gruntfest (*8*) have pointed out that the tearing process is a response to a nonuniform tensile stress. Writing from the standpoint of textile testing, they add that, in principle, it is possible to relate tear behavior to performance in the tensile test provided the stress pattern can be defined. This, in turn, depends largely on the shape of the load–elongation curve (*8*).

Factors in the Behavior of Saturated Paper

Unlike textile materials, the matrix of fibers constituting a typical saturating paper has relatively little tear strength, as indicated above, and substantially no effect of rate of loading is observed. The saturants are viscoelastic polymers whose load–elongation behaviors are markedly affected by rate of straining. It would be expected, therefore, that the performance of the paper-polymer combination would depend strongly on polymer type and on interaction of polymer with fibers. These factors would control tensile strength and stretch. Moreover, the elongation beyond the elongation cor-

Table III. Comparison of Results of Rate Study with Standard Tear Tests

Polymer[a]	Edge tear strength, lb./in. width		Rate at maximum edge tear strength, in./min.	Trapezoid tear strength, lb.		Rate at maximum trapezoid tear strength, in./min.
	Standard Value[b]	maximum		Standard value[c]	Maximum	
A	23.7	25.0	20.0	1.30	1.40	1.00
B	31.5	29.9	4.6	0.83	1.20	0.40
C	21.5	≥27.1	≤0.5	0.70	1.60	0.10
D	18.7	25.3	5.6	0.57	>0.80	<0.02
E	36.1	31.7	4.3	0.69	1.24	0.11
F	33.6	33.7	6.4	0.70	2.00	0.54
G	31.3	32.9	10.0	1.68	2.02	1.10
H	5.6	16.1	5.0	0.38	0.42	0.50
K	23.8	29.1	15.5	1.26	1.30	2.8
L	29.0	29.8	12.0	1.47	1.52	1.2
M	3.9	≥4.3	≤0.5	0.30	0.34	0.2

[a] See Table II for description of these polymers. All were used at 75–79% on fiber in base paper 1 (Experimental Section).
[b] TAPPI Standard T 470 m-54.
[c] ASTM Standards Part 7 Standard No. D39-49 (2.0 in. per min.).

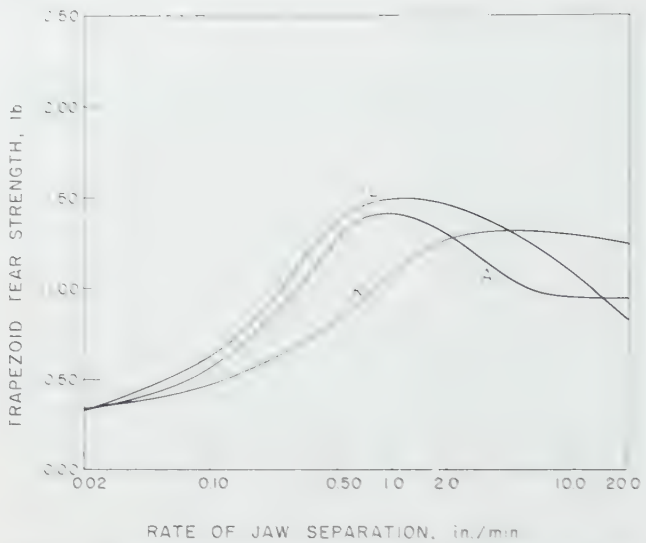

Fig. 1. Effect of rate of jaw separation on trapezoid tear strength

Polymer A: poly(ethyl acrylate 100); polymers K and L: (polybutadiene 66, acrylonitrile 34).

responding to maximum load is important. This is so because the level of tear strength depends on ability of elements some distance in front of the advancing tear to bear load. Elongation of the failing element beyond the point of maximum load facilitates distribution of stress by movement of polymer films and associated fibers.

It is theorized that the shapes of the curves relating tear strength to rate of jaw separation are determined by (a) flow behavior of the greatly attenuated polymer films between and surrounding the fibers and (b) intensity of interaction of these films with the fibers (adhesive strength). Both tendencies would be modified by the presence in the polymer of polar functional groups capable of generating intermolecular bonds in the saturant (cohesive strength), or between saturant and fiber (adhesive strength). Failure at high rates

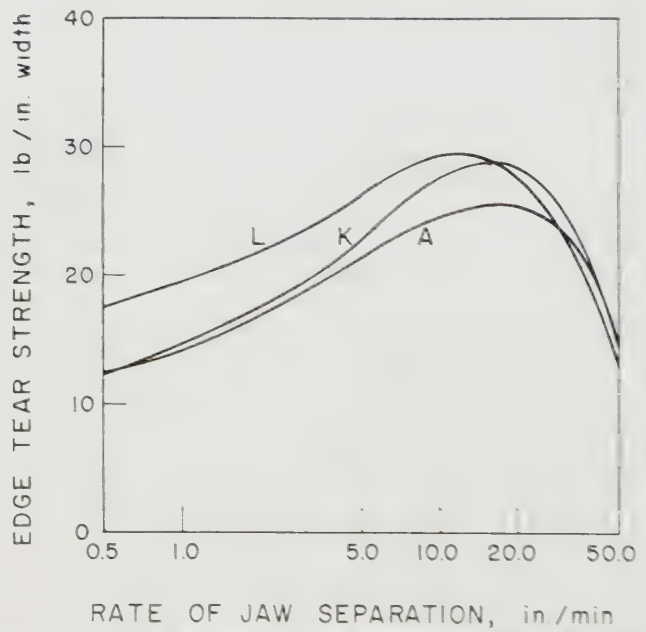

Fig. 2. Effect of rate of jaw separation on edge tear strength

Polymer A: poly(ethyl acrylate 100); polymers K and L: (polybutadiene 66, acrylonitrile 34).

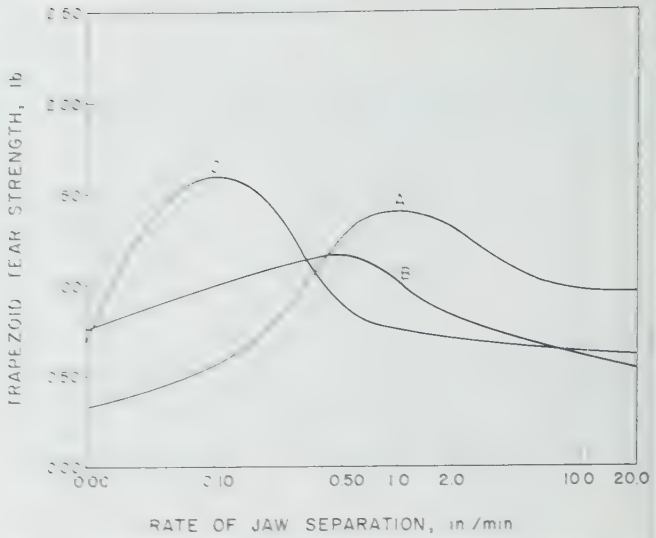

Fig. 3. Effect of rate of jaw separation on trapezoid tear strength

Polymer A: poly(ethyl acrylate 100); polymers B and C: copolymers of ethyl acrylate with low levels of amide or carboxyl-containing monomers.

of loading could result from good adhesion to fibers, with consequent lowered capacity to stretch and adapt. To throw some light on the tearing process and on the nature of bonding in saturated paper, variations were made in polymer composition (functional comonomers), molecular weight, and emulsifier type, and in the nature of base paper. The rate dependence of tear of the corresponding saturated papers was measured.

Effect of Functional Groups

Poly (ethyl acrylate), A in Table II, and two polymers principally of ethyl acrylate but containing functional groups (B and C) were compared as shown in Fig. 3. Polymer B (amide type) contributes higher trapezoid tear strength at low rates and attains maximum strength at a lower rate than the nonfunctional polymer. Beyond this rate, tear strength decreases, falling below the values for A. Polymer C (carboxyl type) attains maximum strength at a lower rate than

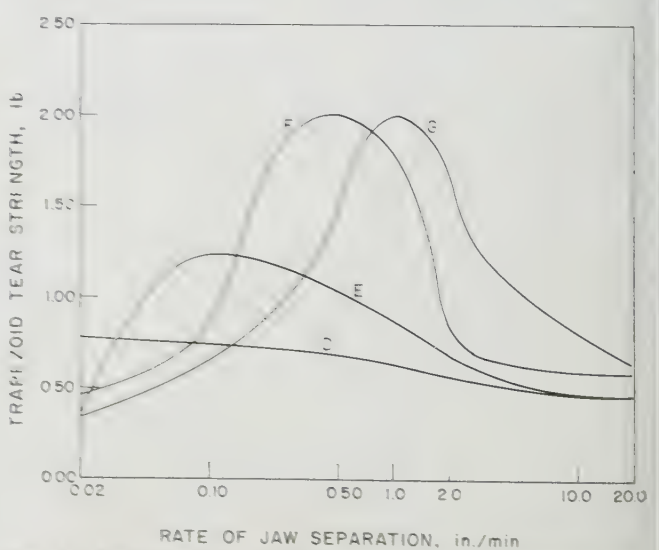

Fig. 4. Effect of rate of jaw separation on trapezoid tear strength

Copolymers of ethyl acrylate and methyl methacrylate. D: normal molecular size; E, F, G.: reduced molecular size.

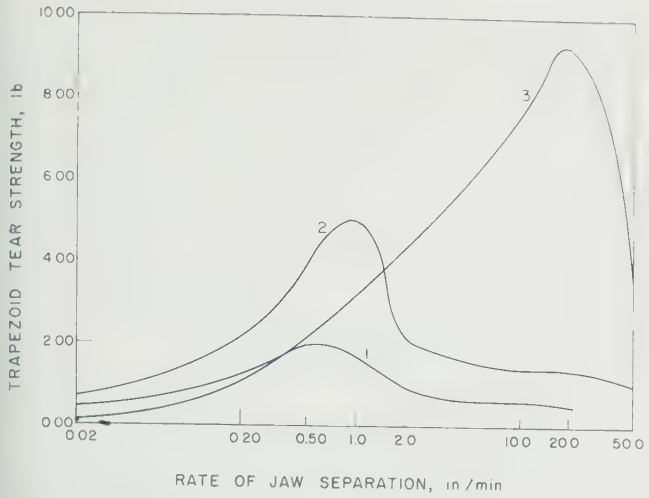

Fig. 5. Effect of rate of jaw separation on trapezoid tear strength

Polymer F (ethyl acrylate 90, methyl methacrylate 10) in base papers 1, 2 (cellulose) and 3 (60% Dacron 40% cellulose).

B or A, and the measured strength is appreciably higher at this optimum rate.

The results are in harmony with the view that polymers B and C adhere to cellulose more tenaciously than A. From independent data on bonding strength in pigmented coatings on cellulose, it is known that the carboxylic structure of C is more efficient than the amide structure of B in conferring adhesion. Good adhesion has resulted in high tear strength at low rates of loading. Presence of functional groups has probably also enhanced cohesive strength of the polymer films. However, at high rates of loading (including the standard rate of 2.0 in. per min.) good adhesion to fiber prevents adequate movement of polymer films to distribute the load.

Effect of Molecular Weight and Functional Group Content

A polymer (D) having excellent adhesion to cellulose was compared with three polymers (E, F, G) of lowered and closely similar molecular weight ($\bar{M}_v$/*ca.* 119,000 compared with 3,240,000 for D). E is identical to D in monomer composition, differing only in $\bar{M}_v$. All three showed greatly enhanced trapezoid tear strength over most of the range of rates (Fig. 4). Trapezoid tear was progressively raised and maximum shifted to higher rates of jaw separation as the functional groups changed from carboxyl to amide and the level of amide was reduced (E-F-G).

At the lowest rate, the superior cohesive strength of saturant D-paper-combination is observed, but inability to adapt to the rapidly applied strain at higher rates causes a steady reduction of tear strength. Reduction of molecular weight weakens interaction of polymer with fiber and permits ready adaptation of the films during straining.

Table IV. Acrylic Polymers A and B in 60% Dacron Paper

	Edge tear strength, lb./in. width at jaw-separations				
		rate (in./min.) of			
Polymer[a]	*0.5*	*5.0*	*10.0*	*20.0*	*50.0*
A	9.2	16.5	19.9	23.1	30.8
B	17.1	27.0	26.1	26.9	24.7

[a] 75–79% on fiber (base paper 3). See Table II for description of polymers.

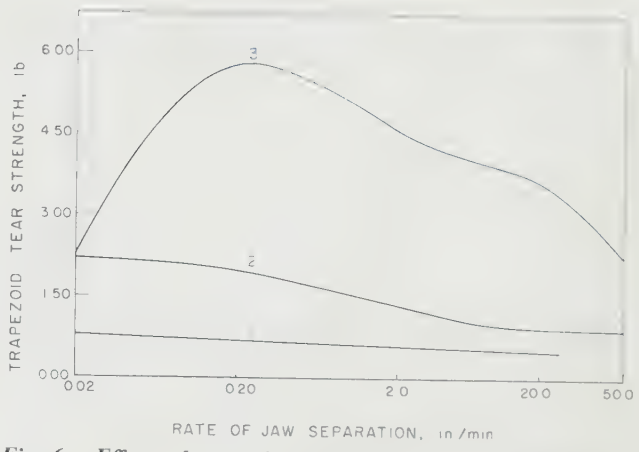

Fig. 6. Effect of rate of jaw separation on trapezoid tear strength

Polymer D (ethyl acrylate 89, methyl methacrylate 11) in base papers 1, 2 (cellulose) and 3 (60% Dacron 40% cellulose).

The superiority of F to E results from substitution of the less tenaciously adhering amide structure for carboxyl, and that of G to F results from reduction in amount of amide function (a 50% reduction: Table II).

It is possible that the difference shown in Fig. 1 between two polymers of identical composition (K, L: poly (butadiene-acrylonitrile) may be traceable, in part, to a molecular weight difference.

Comparison of Standard Tear Tests with Results of Rate Study

Table III summarizes the results shown in Figs. 1–4, as well as results of tests of polymers H (relatively hard acrylic ester polymer) and M (vinyl acetate homopolymer). These are compared with the standard edge tear and trapezoid tear tests. Polymers A, K, L, and M, containing no polar functional groups, show maximum trapezoid tear strengths which do not differ greatly from the standard values (at 2.0 in. per min.). This is not true, however, for the functional types (B-G) all of which show much higher values than the standard value at some lower rate.

Effect of Fiber Type and Degree of Refinement

Interaction between polymeric saturant and fiber can be reduced not only by removal of functional comonomers but also (a) by substitution of fibers toward which typical hydrogen-bonding groups show no specific adhesion or, (b) by use of cellulose fibers which have been less extensively refined. In both cases the interaction between saturant and fiber is weakened, maximum tear strength is raised, and the maximum appears at a higher rate of loading. This is illustrated in Fig. 5, where the behavior of Polymer F (an acrylic

Table V. Effect of Emulsifier in Polymer Synthesis: Edge Tear Strength–Rate Dependence

		Edge tear strength (lb./in. width) at jaw-separation rate (in./min.) of				
Polymer[a]	*Test direction*	*0.5*	*5.0*	*10.0*	*20.0*	*50.0*
E	M.D.	30.7	18.2	15.4	6.5	4.3
E	C.D.	22.8	31.6	27.4	21.0	7.2
E	M.D.	27.9	25.5	18.0	8.5	3.8
E	C.D.	17.7	29.1	26.5	14.3	5.3

[a] 75–79% on fiber (base paper 1). See Table II for description of polymers.

Table VI. Comparison of Tear Strengths With Data From Load–Elongation Curves of Various Saturated Papers

Polymer[a]	Edge tear strength, lb./in. width	Trapezoid tear strength, lb.	Tensile strength,[b] lb./in. width	Elongation,[c] %	Toughness[d]
F	31.0	0.70	10.0	58	290
E	29.2	0.69	15.3	58	445
B	28.6	0.83	16.1	24	195
L	23.5	1.47	12.1	41	250
D	23.5	0.57	17.9	19	170
G	21.8	1.68	13.0	57	369
A	18.5	1.30	9.6	39	188
K	18.5	1.26	11.7	32	187
H	11.5	0.38	17.7	15	142
M	4.0	0.30	29.0	8	118

[a] See Table II for description of these polymers. All were used at 75–79% on fiber in base paper 1.
[b] All tear and tensile data were obtained with the Instron tester at a jaw separation rate of 2.0 in. per min. (100% per min. rate of strain in the case of the load–elongation curves).
[c] Measured to the point where load had fallen to 25% of the maximum load.
[d] Tensile strength times % elongation divided by 2.

ester copolymer of reduced molecular weight) is shown in three papers.

Substitution of a cellulose sheet (base paper 2) formed from less beaten fibers more than doubles the maximum trapezoid tear strength and shifts the rate for this maximum to a higher value. Introduction of 60% of Dacron fibers (base paper 3) has an even more pronounced effect, raising trapezoid tear strength to over 9.0 lb. at the optimum rate of 20 in. per min. At low rates this saturated paper is relatively weak, reflecting the low cohesion in the saturant and weak interfiber bonds.

Similar results were realized with polymer D (normal molecular weight, carboxyl type), maximum strength and optimum rate being raised considerably with paper 3 from relatively low values for the cellulose papers (Fig. 6).

When polymers A and B were saturated into 60% Dacron paper and edge tear strength measured, the results of Table IV were obtained. As with trapezoid tear strength in all-cellulose paper (Fig. 3), the jaw-separation rate for maximum edge tear strength was higher for the nonfunctional polymer (A). The rates were 5.0 and over 50 in. per min. for B and A, respectively, compared with 4.6 and 20 in. per min. for edge tear strength in all-cellulose paper (Table III).

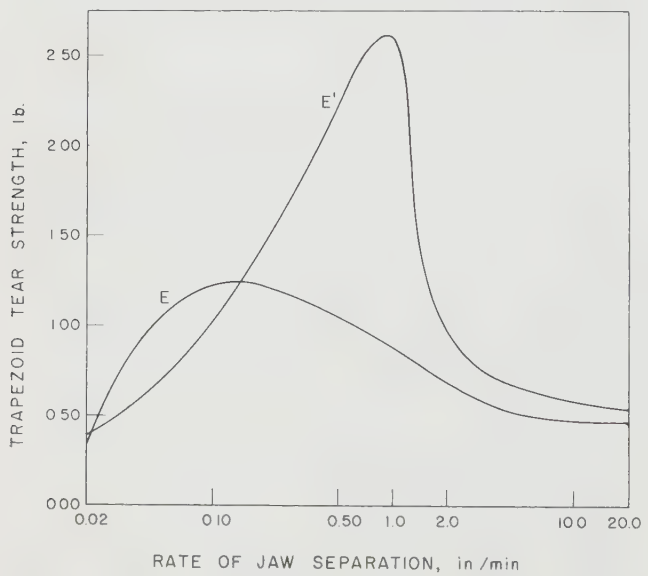

Fig. 7. Effect of rate of jaw separation on trapezoid tear strength

E and E[1]: copolymers of ethyl acrylate, methyl methacrylate and acid comonomer, reduced molecular size; prepared with nonionic and anionic emulsifiers, respectively.

The enhancement of the difference between these saturants is probably due to reduced interfiber bonding and reduced adhesion of polymer-to-fiber in the case of polymer A, permitting greater stretch at high rates.

Effect of Emulsifier Used in Polymer Synthesis

Substitution of an anionic for a nonionic soap in the preparation of polymer E (Table II) gave a polymer E[1] whose contribution to edge and trapezoid tear strengths was differently affected by rate. Trapezoid tear data are shown in Fig. 7. The anionic soap for E[1] appears to have weakened adhesion of polymer to fiber, lowering tensile strength somewhat, but greatly increasing elongation.

Edge tear strengths at various rates in cellulose paper are given in Table V for E and E[1]. The differences are less pronounced than with trapezoid tear and 60% Dacron paper. Over the entire range, tear strength (cross-direction) has been lowered by use of the anionic soap, although, optimum rate has not been shifted appreciably. The machine-direction samples of E[1]-containing paper showed higher tear strengths for some of the intermediate rates.

Correlation of Tear Data With Other Paper Properties

The resemblance of the tear-rate relationships to some tensile strength versus rate curves suggested a comparison to see whether the ranking of saturants according to optimum rate would be similar for tear and tensile strength. A satisfactory comparison could not be made because some of the saturated papers did not show maximum tensile strengths below rates of 20 in. per min. (1000% per min); accurate measurement could not be made.

For textile fabrics, an empirical relationship has been found between trapezoid tear strength and toughness, defined as one-half the product of breaking strength and extensibility (7). Comparison of this property with trapezoid tear strength (both measured at 2.0 in. per min.) did not show any strong correlation (Table VI) and use of the actual area under the load–elongation curve did not improve the relation. Correlation of edge tear strength at the same rate of jaw separation with toughness was somewhat better, but still far from satisfactory (Table VI).

The load–elongation curve of a typical saturated paper differs from that of a textile fabric in showing a pronounced concavity toward the elongation axis. Particularly with the softer saturants, that portion of the curve lying beyond the point of maximum load may be as extended as the portion of the curve repre-

senting rising load. Breaking-strength (taken as the maximum load) and elongation (taken at the point where load had fallen back to 25% of maximum) thus do not correspond to the same point on the curve, as with textiles. Moreover, the processes occurring in the paper, after elongation to maximum load has been exceeded, really resemble tearing. Although the capacity of the paper to extend in this way permits distribution of load in the tear test, the relationship is probably quite complex.

CONCLUSIONS

A satisfactory correlation of rate-dependence of tear strength with other paper properties and their variation with rate has not been obtained. It is clear, however, that measurement of tear strength over a range of rates provides an insight into the flow behavior and cohesive strength of polymeric saturants not readily attainable with free films of these polymers. Even at moderate rates of jaw separation, the extremely thin films surrounding the fiber matrix are undoubtedly subjected to extremely high rates of straining. The tear strength-rate relationship also gives, at least qualitative, information about interfiber bonding and adhesion of fiber to saturant. One practical outcome of this study will be the development of polymers effective as paper saturants over a wider range of conditions of end-use.

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Wet-Bulb Hygrometry for the Air-Water Vapor-Sulfur Dioxide System

PATRICK J. McKEOUGH, GLENN W. HUEBNER, and W. R. MARSHALL, JR.

Experimental measurements were made of wet-bulb temperatures in the presence of air, water vapor, and sulfur dioxide to study the feasibility of determining the humidity of such a system by wet-bulb thermometry. It was found that the wet-bulb temperatures of a 20 mole % SO_2 system were consistently higher at a given molal humidity than the wet-bulb temperature for the corresponding sulfur dioxide-free system. Consequently, the slopes of the wet-bulb temperature lines versus molal humidity were steeper with sulfur dioxide present. A theoretical prediction of the slopes of the wet-bulb temperature lines based on the heat and mass transfer properties of the sulfur dioxide system did not agree with the experimental values. The discrepancy was attributed to uncertainties as to the true diffusion mechanism in the gas film surrounding the wet bulb. It was found, however, that the slopes of the wet-bulb lines could be more closely approximated by the slopes of the adiabatic saturation lines because the humid heat increases with the sulfur dioxide content. A humidity chart for a 20 mole % SO_2 mixture was prepared on which wet-bulb temperature lines were plotted for 20 mole % SO_2 and for sulfur dioxide-free systems.

It is often necessary to determine the water vapor content of industrial gases which contain gaseous components other than air. Some of the commonly occurring industrial gases are sulfur dioxide, carbon dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, etc. An example of one specific need of this kind is the determination of the humidity of sulfur dioxide-laden gases from sulfur burners after having been passed through cooling towers. The investigation reported here was suggested for this specific problem by A. W. Plummer (7), and the research was concerned with the possibility of applying wet-bulb thermometry techniques to the measurement of the humidity of air with sulfur dioxide present in varying percentages. One practical goal of the study was the preparation of a humidity chart for the three component system air-water vapor-sulfur dioxide gas in which the wet-bulb temperature lines were experimentally confirmed. Such a chart would be useful for making a rapid determination of the humidity of gases from sulfur burners after they have passed through cooling towers.

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NOMENCLATURE

A_h	=	area for heat transfer, sq. ft.
A_m	=	area for mass transfer, sq. ft.
c_p	=	mean specific heat of gas film around wet bulb, B.t.u. per (lb.) (°F.)
$(C_p)_v$	=	specific heat of water vapor
c_s	=	humid heat = $c_p + (C_p)_v H$, B.t.u. per (°F.) (lb. dry gas) (can also be on a mole basis)
D_v	=	diffusion coefficient in binary system, sq. ft. per hr.
D_{vm}	=	mean diffusion coefficient in multicomponent system, sq. ft./hr.
D_{va}	=	diffusion coefficient of water vapor in air, sq. ft. per hr.
D_{vSO_2}	=	diffusion ccefficient of water vapor in SO_2, sq. ft. per hr.
H	=	absolute humidity, lb. per lb. basis, eq. (3); lb. mole per lb. mole basis, Eq. (6)
H_a	=	humidity of air, lb. or lb. mole H_2O per lb. or lb. mole dry gas

H_s = saturation humidity corresponding to temperature of adiabatic saturation
H_w = saturation humidity corresponding to wet-bulb temperature
h = total heat transfer coefficient, B.t.u. per (hr.) (sq. ft.) (°F.)
h_c = heat transfer coefficient for convection, B.t.u. per (hr.) (sq. ft.) (°F.)
h_r = heat transfer coefficient for radiation, B.t.u. per (hr.) (sq. ft.) (°F.)
k_f = average thermal conductivity of gas film around wet bulb, consistent units
k_g = mass transfer coefficient, lb. per (hr.) (sq. ft.) (unit vapor pressure difference)
k'_g = mass transfer coefficient based on humidity driving force with humidity expressed in lb. H_2O per lb. dry gas
k''_g = $k'_g M_g/M_v$
m = slope of wet-bulb temperature lines
m_a = slope of wet-bulb temperature lines for air-water vapor only
m_{SO_2} = slope of wet-bulb temperature lines for air-SO_2-H_2O
M_g = molecular weight of gas
M_v = molecular weight of vapor
p_a = partial pressure of water vapor in air
p_{gf} = average pressure of nondiffusing components in the gas film surrounding the wet bulb
p_w = vapor pressure of water at temperature t_w
P = total pressure
t_a = dry-bulb temperature of surrounding air
t_w = wet-bulb temperature
y = mole fraction in gas film
y_a = mole fraction of air in gas film
y_v = mole fraction of water vapor in gas film
y_{SO_2} = mole fraction of sulfur dioxide in gas film

Greek Symbols

ΔH_s = heat of solution of sulfur dioxide in water, B.t.u. per lb. SO_2 absorbed
λ_w = latent heat of evaporation at wet-bulb temperature, B.t.u. per lb.
μ = viscosity gas mixture in film around the wet bulb, consistent units
ρ = density of gas film around wet bulb, consistent units

THE PRINCIPLE OF WET-BULB THERMOMETRY

Wet- and dry-bulb thermometry, when applicable, is a practical and preferred method for determining humidity in industrial applications. In this method, a thermometer with its bulb surrounded by a wetted wick is immersed in the test gas stream and its equilibrium temperature read together with the dry-bulb gas temperature. In partially saturated gas, the wet-bulb temperature will always be lower than the dry-bulb temperature. The gas humidity is then read from an appropriate psychrometric chart at the corresponding wet- and dry-bulb temperatures, or calculated from suitable equations.

The wet-bulb thermometer has long been a familiar device for determining the water vapor content of air in connection with atmospheric humidity measurements in meteorology and in industrial operations such as drying, air conditioning, cooling tower operations, etc. This method depends on the evaporative cooling experienced by a thermometer when it is encased in a wetted wick and inserted into a flowing stream of moist gas the humidity of which is desired, Fig. 1a. The amount of cooling of the wet-bulb or the wet-bulb temperature depression, Fig. 1b, is a function of the degree of unsaturation of the flowing air. Quantitative expressions based on simultaneous heat and mass transfer have been developed for estimating the wet-bulb temperature of air-water vapor mixtures, and semitheoretical expressions have been proposed for other systems which might include systems such as air, water vapor, and sulfur dioxide gas.

By assuming an equilibrium between heat and mass

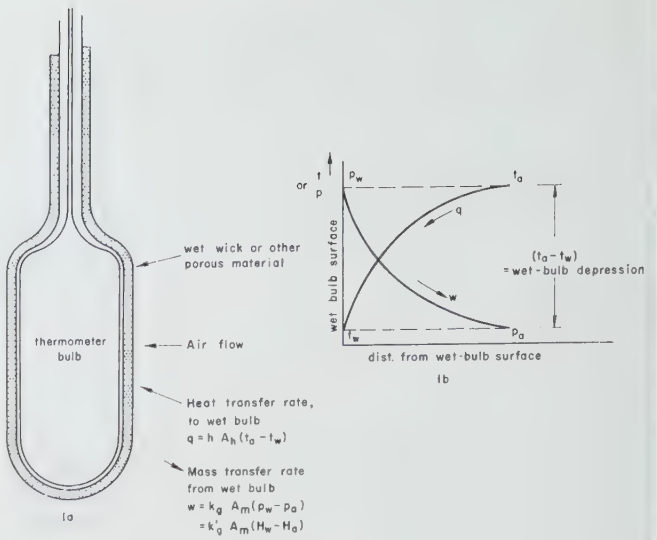

Fig. 1

transfer rates, Fig. 1, the wet-bulb temperature of a gas, t_w, may be expressed by the following equation:

$$hA_h(t_a - t_w) = \lambda_w k_g A_m(p_w - p_a) \qquad (1)$$

where

h = the total heat transfer coefficient between the wet-bulb and its surroundings, B.t.u. per (hr.) (sq. ft.) (°F.)
A_h = area for heat transfer, sq. ft.
$(t_a - t_w)$ = difference between dry-bulb and wet-bulb temperatures of the gas, respectively, Fig. 1. (Also termed wet-bulb depression)
λ_w = latent heat of evaporation at t_w, B.t.u. per lb.
k_g = gas film mass transfer coefficient, lb. per (hr.) (sq. ft.) (unit vapor pressure difference)
A_m = area of mass transfer, sq. ft.
p_w = vapor pressure of water at t_w
p_a = partial pressure of water vapor in the air at temperature t_a

The heat transfer coefficient, h, is a combination of convection and radiation coefficients, h_c and h_r, respectively. Thus, $h = h_c + h_r$. In making wet-bulb measurements, it is important to adjust the gas velocity over the bulb such that h_c will be the predominant coefficient. The recommended velocity is about 16 ft. per sec. (*4*).

Equation (1) is a simplified expression of the dynamic equilibrium between the rate of transfer of heat to the wet bulb and the corresponding rate of mass transfer from the wet bulb since it does not take into account sensible heat transfer to the vapor leaving the wet bulb. However, this effect is not significant at air temperatures below 800°F.

It has been found convenient to replace the vapor pressure driving force term $(p_w - p_a)$, by the humidity driving force $(H_w - H_a)$, where $H_w = [p_w/(P - p_w)]\, M_v/M_g$ and $H_a = [p_a/(P - p_a)]\, M_v/M_g$. M_v and M_g are the molecular weights of water vapor and gas, respectively. Thus, the mass transfer coefficient, k_g, is modified to k'_g by the following relationship:

$$k'_g = k_g p_{gf} M_g/M_v \qquad (2)$$

where p_{gf} represents an average value of $(P - p_w)$ and $(P - p_a)$, i.e., the pressure of inert gas in the film surrounding the wet bulb, and is moved out of the parentheses on this basis. Rewriting equation (1) in terms of k'_g and humidities, and rearranging, we can obtain:

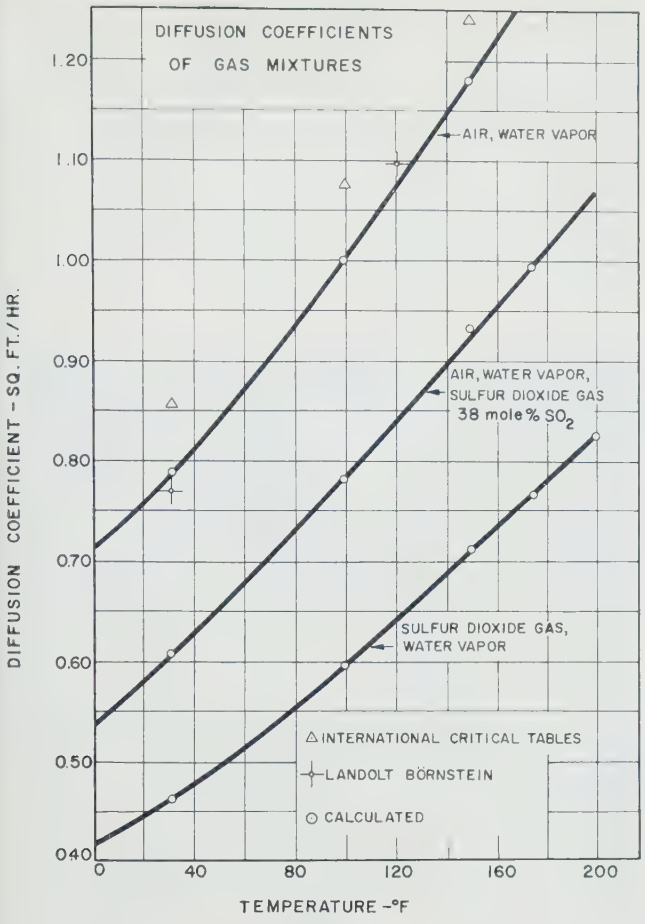

Fig. 2

$$\frac{h_c}{k'_g} = \frac{\lambda_w(H_w - H_a)}{(t_a - t_w)} \qquad (3)$$

The ratio h_c/k'_g has been termed the psychrometric ratio and it represents the ratio of thermal transport properties to mass transport properties. In equation (3), h has been replaced by h_c, since convection heat transfer predominates. A knowledge of this ratio would permit the estimation of humidities from wet-bulb temperature measurements because as equation (3) shows, the psychrometric ratio is directly related to the slope of the wet-bulb lines on a humidity chart.

For air-water vapor systems the psychrometric ratio is approximately 0.24; however, for organic liquids this ratio may range up to a value of 0.6. Values of the ratio for several different vapor-air systems are given in reference (*9*).

A semitheoretical prediction of the psychrometric ratio based on the Chilton-Colburn analogy (*3*) is given by:

$$\frac{h_c}{k'_g} = c_s \left(\frac{\mu/\rho D_v}{c_p \mu/k_f}\right)^{2/3} \quad c_s = \left(\frac{k_f}{D_v \rho c_p}\right)^{2/3} \qquad (4)$$

while an empirical expression developed by Bedingfield and Drew (*1*) is:

$$\frac{h_c}{k'_g} = 0.294 \left(\frac{\mu}{\rho D_v}\right)^{0.56} \qquad (5)$$

where

c_s = humid heat of the gas film mixture
c_p = average specific heat of the inert gas mixture
μ = average viscosity of the vapor-gas mixture
ρ = average density of the vapor-gas mixture
D_v = diffusivity of the vapor into the gas mixture
k_f = thermal conductivity of the gas mixture

WET-BULB TEMPERATURES OF MULTICOMPONENT SYSTEMS

No values of h_c/k'_g, either experimental or calculated,

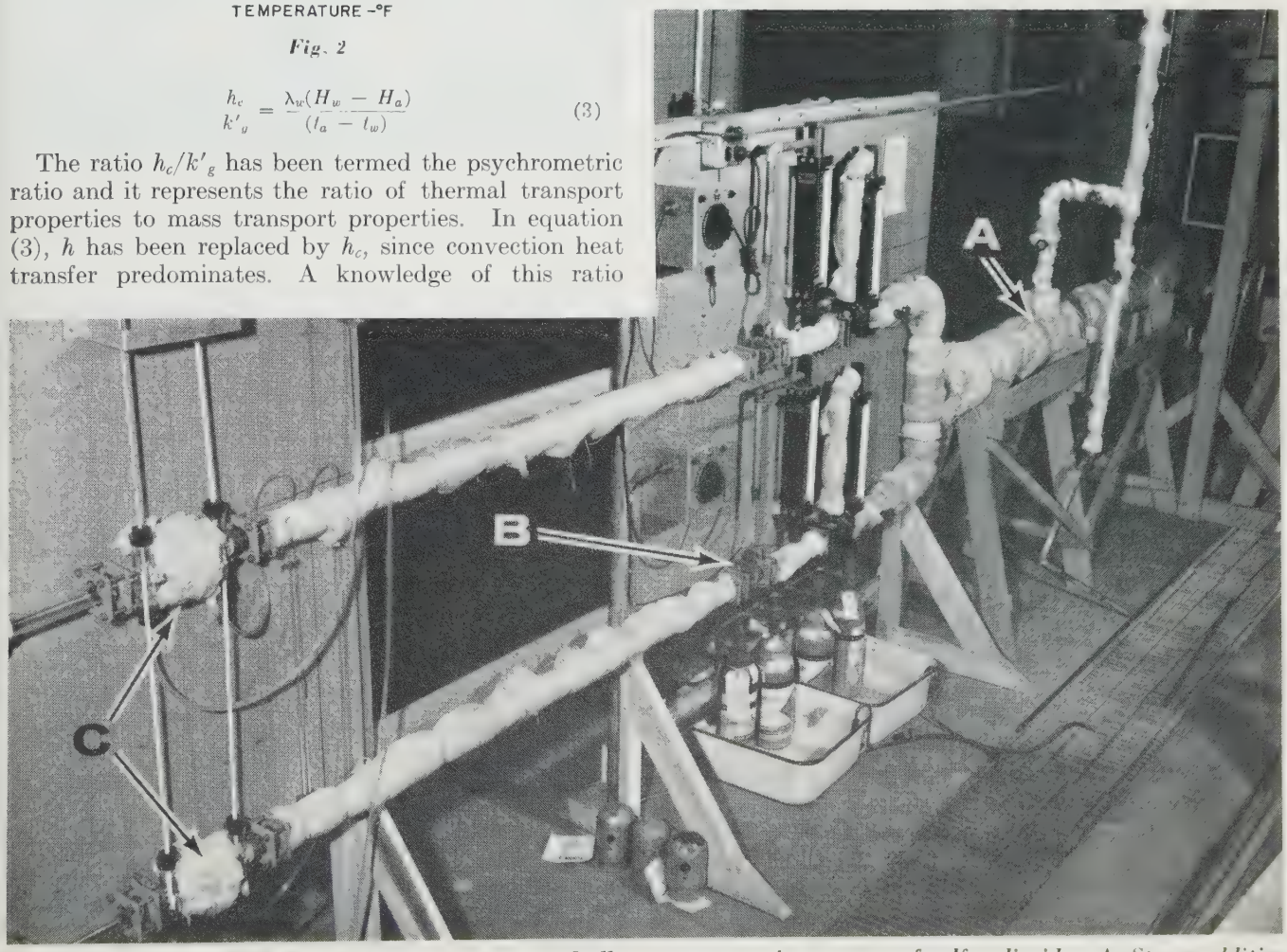

Fig. 3. Experimental equipment for measuring wet-bulb temperatures in presence of sulfur dioxide. A, Steam addition for humidification. B, SO_2 addition. C, Wet-bulb temperature test sections

have been reported for multicomponent systems such as water vapor-air-sulfur dioxide. In order to predict such values from either equation (4) or equation (5), values of the multicomponent transport properties, viscosity, diffusivity, and thermal conductivity must be available.

It is more convenient to express the humidity driving force on a mole basis for multicomponent systems, i.e., humidities are written as pound moles of water per pound mole of dry gas.

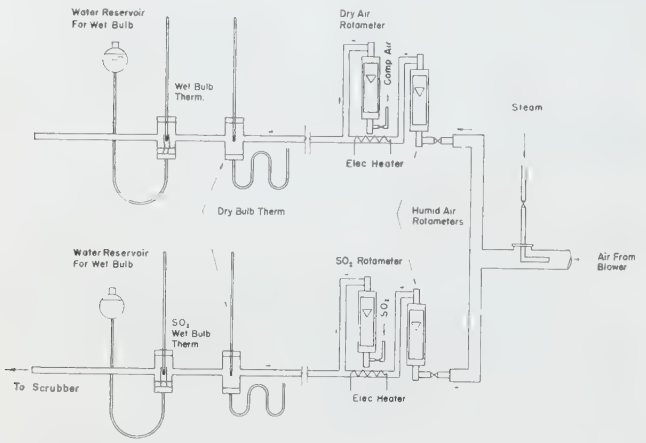

Fig. 4. Diagram of experimental equipment for wet-bulb temperature measurements

If the wet-bulb temperature is written explicitly from equation (1) on a mole basis:

$$t_w = t_a - \frac{\lambda_w k''_g A_m}{h_c A_h} (H_w - H_a) \qquad (6)$$

where $k''_g = k'_g/1.6$. Hence $(h_c/k''_g) = 1.6\,(h_c/k'_g)$ for air-water vapor only.

If the ratio of transfer coefficients can be calculated properly from transport properties and equation (4), then the wet-bulb temperature for multicomponent systems can be predicted from equation (6). Or conversely, if the wet-bulb temperature is measured, the humidity can be calculated from equation (6).

From equation (6) it is apparent that the wet-bulb temperature for any given system will be dependent primarily on the transport properties of the system as reflected in the heat and mass transfer coefficients, and on the vapor pressure of water over whatever aqueous solution exists on the wet bulb; e.g., in the case of a sulfur dioxide-air-water vapor system, the vapor pressure of water over solutions of sulfur dioxide. The transport properties involved are the diffusivity of water vapor and the thermal conductivity and viscosity of the mixture surrounding the wet bulb. Since experimental data on these properties are not usually available, it is necessary to estimate them from theoretical expressions for multicomponent systems

The estimation of diffusion coefficients and thermal conductivities for multicomponent systems is not a simple calculation. By means of procedures similar to those developed by Bird, Hirschfelder, and Curtiss, values of the diffusion coefficients and thermal conductivity for the air-water vapor-sulfur dioxide gas system were computed (*6*). The equations used to evaluate diffusivities and thermal conductivities for the sulfur dioxide-air-water vapor system are involved, and their solutions require many pages of calculation. Examples of such calculations may be found in reference (*6*). The results of calculations for the diffusion coefficients for air-water vapor, sulfur dioxide-water vapor, and one air-water vapor-sulfur dioxide mixture are shown in Fig. 2 as functions of temperature. It should be noted that the presence of sulfur dioxide markedly affects the diffusion coefficient.

After the diffusion coefficient and the thermal conductivity of the gas mixture have been calculated, equation (4) may be used to estimate the ratio of the heat transfer coefficient to the mass transfer coefficient. With the proper value of this ratio and equation (6), lines of constant wet-bulb temperature can be predicted and drawn on a humidity chart for the air-water vapor-sulfur dioxide system.

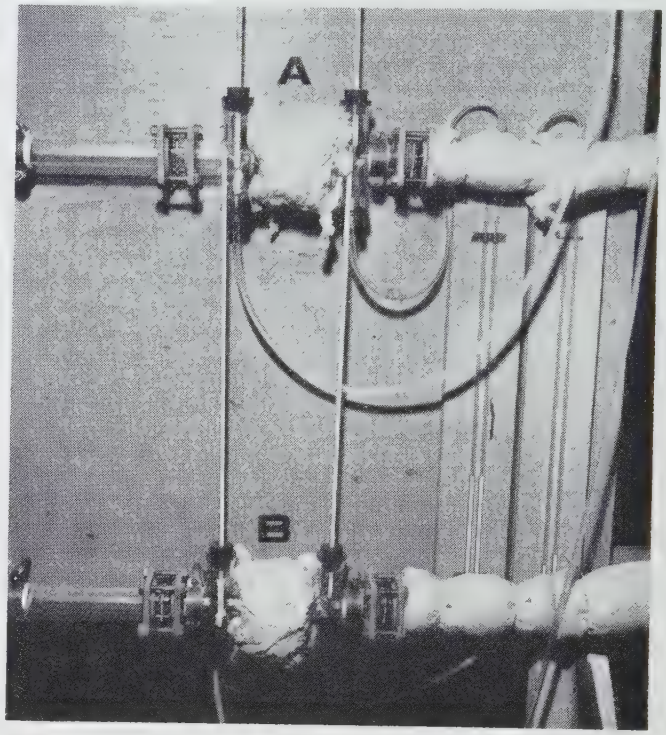

Fig. 5. Closeup of test sections for wet- and dry-bulb temperature measurements. A, SO_2-free stream. B, SO_2 stream

EXPERIMENTAL PROCEDURE

The experimental investigation reported in this paper had as its objective the determination of the psychrometric ratio for the air-sulfur dioxide-water vapor system, from measured wet- and dry-bulb temperatures for the system.

The experimental procedure utilized a system of two parallel streams of humid air, Fig. 3, one of which contained sulfur dioxide and the other was sulfur dioxide-free. Simultaneous measurements of wet- and dry-bulb temperatures were made in each stream. Since the two streams came from a common source of humid air, the water vapor content of the sulfur dioxide-free stream was determined from the wet-bulb temperature. This then became a measure of the water vapor in the sulfur dioxide-containing stream. Figure 4 shows a diagrammatic sketch of the arrangement of the ex-

Table I. Experimental Data

H_a and H_w on lb. mole basis t_a and t_w, °F.

Run no.	Sulfur dioxide-free stream t_a	t_w	H_w	Both streams H_a	Sulfur dioxide-containing stream t_a	t_w	H_w
					20% SO_2		
1	88.5	60.4	0.018	0.0077	87.2	60.8	0.0183
2	89.3	62.4	0.0192	0.0094	88.9	63.2	0.0199
3	90.9	64.0	0.02065	0.0103	91.2	65.2	0.0215
4	87.9	63.2	0.0199	0.01085	87.4	63.9	0.0205
5	85.2	64.4	0.02073	0.0131	84.2	65.0	0.0212
6	83.8	59.3	0.01726	0.0082	80.4	59.0	0.0171
7	90.1	61.8	0.01898	0.0086	86.7	61.7	0.0188
8	103.0	65.7	0.0216	0.0081	101.0	65.6	0.022
9	85.1	62.4	0.01924	0.0113	84.4	63.2	0.0199
10	110.5	73.8	0.0288	0.016	107.5	73.7	0.029
11	107.0	85.8	0.0432	0.035	104.5	85.8	0.0432
12	91.1	85.3	0.0425	0.0405	89.3	85.2	0.0425
13	91.9	86.2	0.0437	0.0415	89.8	86.0	0.0437
14	94.4	73.6	0.0286	0.0208	93.3	73.7	0.0285
15	95.5	75.2	0.0302	0.0228	93.5	74.9	0.0301
16	86.8	74.0	0.029	0.0240	85.7	74.0	0.0291
17	124.0	95.8	0.0599	0.0490	119.5	94.8	0.0578
18	127.0	90.2	0.05	0.0365	124.0	91.5	0.0524
19	126.5	91.0	0.0515	0.0377	123.0	92.3	0.0533
20	127.5	99.6	0.0685	0.0575	123.5	99.5	0.068
21	127.0	102.4	0.074	0.0650	124.0	102.2	0.0741
22	149.2	87.4	0.0458	0.0222	144.7	87.4	0.0458
23	150.1	114.4	0.1093	0.09425	144.0	113.9	0.1077
24	170.9	104.5	0.08	0.0535	164.4	103.9	0.0782
25	171.9	92.4	0.054	0.0235	165.4	92.8	0.0556
					30% SO_2		
26	...	...	...	0.0228	86.9	74.0	0.029
					10% SO_2		
27	...	...	...	0.0286	88.2	77.6	0.0326

perimental equipment. The air for both streams came from a common blower and heater and was humidified by steam injection. It was then split into two streams and metered through rotameters which permitted obtaining equal flow in both lines. The flow rate in each line was 6.25 c.f.m., which gave a velocity of 20 ft. per sec. over the wet bulb. In the bottom line, sulfur dioxide was injected into the stream through another rotameter to give a specified mole per cent, while a corresponding volume of air, dried by silica gel, was metered into the upper line through a fourth rotameter. Electric heaters in each line permitted precise temperature adjustments as required. The wet-bulb thermometers, Figs. 4 and 5, were maintained continuously wet by a water reservoir in a tube into which the wick from the wet bulb extended. The sulfur dioxide-laden gases from the bottom line passed through a packed tower and were scrubbed by caustic solution.

This experimental procedure was adopted after an extensive attempt had been made to use a recirculating system in which the water vapor content was determined by various analytical procedures. The recirculating system was finally abandoned because the various analytical methods tried for measuring water vapor

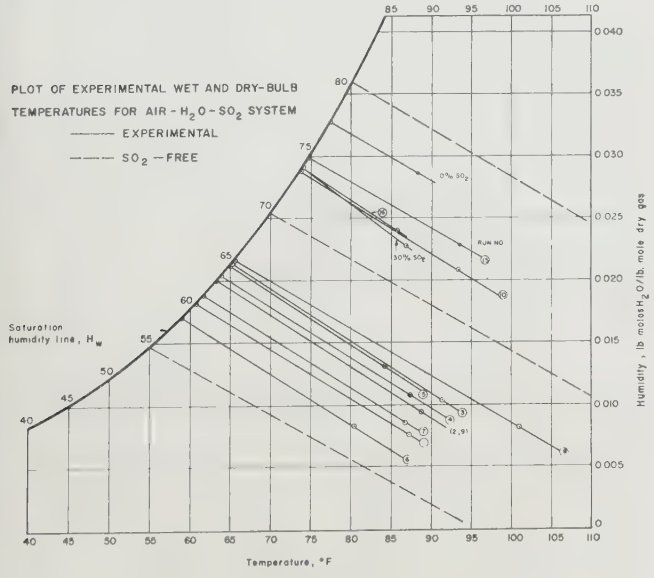
PLOT OF EXPERIMENTAL WET AND DRY-BULB TEMPERATURES FOR AIR - H_2O - SO_2 SYSTEM
EXPERIMENTAL
SO_2 - FREE
Saturation humidity line, H_w
Humidity, lb moles H_2O/lb. mole dry gas
Temperature, °F

Fig. 6

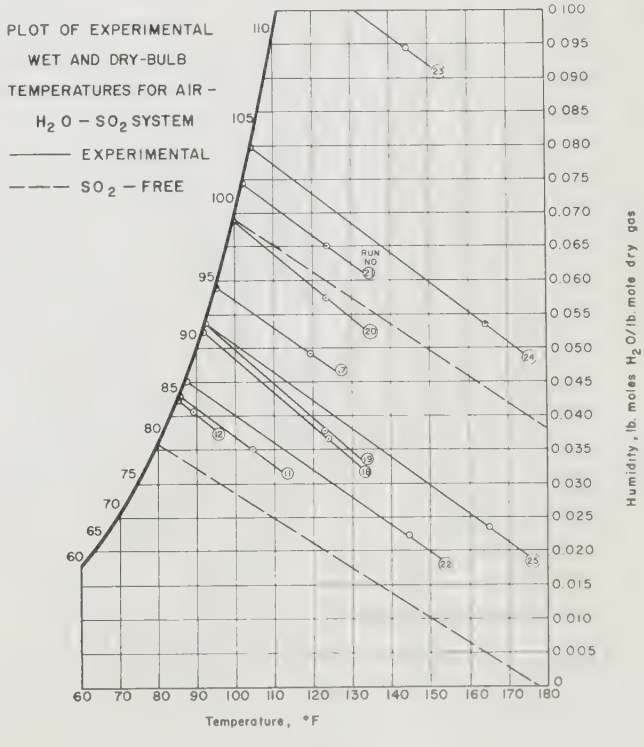
PLOT OF EXPERIMENTAL WET AND DRY-BULB TEMPERATURES FOR AIR - H_2O - SO_2 SYSTEM
EXPERIMENTAL
SO_2 - FREE
Humidity, lb. moles H_2O/lb. mole dry gas
Temperature, °F

Fig. 7

in the presence of sulfur dioxide proved to be too inaccurate and tedious. There were other serious drawbacks such as the gradual increase in humidity as the gas continued to circulate over the wet bulb. The system of parallel streams, however, with dual wet-bulb temperatures permitted direct comparison of measured wet-bulb temperatures with and without sulfur dioxide present. The moisture content of the air was then obtained from a humidity chart.

In making an experimental run, an attempt was made to obtain equal wet-bulb temperatures in the test sections. In order to do this, a small amount of heat was added to the sulfur dioxide-free stream, since it was found necessary to obtain a higher dry-bulb temperature in order to get the same wet-bulb temperature as that obtained in the sulfur dioxide containing stream. The experimental data tabulated in Table I gives a comparison of the wet-bulb depressions for the two streams. These data are also plotted on portions of a humidity chart, Figs. 6 and 7.

H_a = molal humidity determined from a humidity chart at the values of t_w and t_a measured in the sulfur dioxide-free stream

We shall let m_a be the slope for the sulfur dioxide-free stream, and m_{SO_2} the slope for the sulfur dioxide-containing stream. Table II gives values of m_a and m_{SO_2} for all runs made, and for sulfur dioxide concentrations of 10, 20, and 30 mole %. It can be observed that the wet-bulb lines for the 20 and 30 mole % SO_2 systems have a steeper slope than the lines for air-water vapor only.

Table II. Slopes of Wet-bulb Lines and Experimental Values of h_c/k'_g

Run no.	$m_{SO_2} \times 10^4$	$m_{air} \times 10^4$	m_{SO_2}/m_{air}	$m_{SO_2} \times 10^4$ *(adiab. sat. theory)*	$(h_c/k'_g)_{exp}$
	20% SO_2				For 20 mole SO_2, %
1	4.01	3.68	1.09	3.94	0.212
2	4.1	3.65	1.12	3.94	0.216
3	4.3	3.84	1.12	3.95	0.227
4	4.12	3.7	1.113	3.95	0.218
5	4.22	3.67	1.15	3.98	0.222
6	4.15	3.7	1.12	3.9	0.219
7	4.07	3.66	1.11	3.91	0.215
8	3.93	3.62	1.085	3.98	0.207
9	4.05	3.5	1.16	3.95	0.214
10	3.84	3.49	1.10	3.99	0.202
11	4.5	3.87	1.16	4.1	0.235
12	3.9	3.96	1.0	4.12	0.204
13	4.25	3.86	1.10	4.13	0.222
14	4.35	3.75	1.16	4.12	0.228
15	3.83	3.54	1.08	4.02	0.201
16	4.35	3.9	1.14	4.03	0.228
17	3.6	3.86	...	4.19	0.186
18	4.9	3.67	1.33	4.17	0.254
19	5.0	3.88	1.29	4.17	0.259
20	4.37	3.94	1.11	4.23	0.226
21	4.37	3.66	1.194	4.26	0.225
22	4.12	3.82	1.08	4.04	0.215
23	4.46	4.31	1.035	4.43	0.228
24	4.05	3.99	1.02	4.21	0.210
25	4.42	3.83	1.15	4.07	0.229
	30% SO_2				
26	5.17	...	...	...	0.246
	10% SO_2				
27	3.78	...	...	...	0.219

TREATMENT OF DATA

A correlation of the experimental data was attempted by computing the slope of the wet-bulb line which passed through the point corresponding to the saturation humidity at the wet-bulb temperature and the point for the air humidity and dry-bulb temperature, as shown in Figs. 6 and 7. This slope is given by

$$m = \frac{H_w - H_a}{t_a - t_w} \qquad (7)$$

where

H_w = saturation molal humidity corresponding to t_w for the sulfur dioxide-containing stream, lb. mole water vapor per lb. mole dry gas
t_w = measured wet-bulb temperature, °F.
t_a = measured dry-bulb temperature, °F.

For 20% SO_2, the slope is 12 to 16% steeper, and for 30% SO_2, it is on the order of 30% steeper. The 10% SO_2 line shows little difference from the air-water vapor line.

The values of m_a are essentially measures of the accuracy with which H_a was graphically determined. This is because the values of H_a were determined from adiabatic saturation lines whose slopes are given by c_s/λ_s, equation (8), below. Therefore, the slopes are subject to *a priori* calculation, and they should have a value of about 3.8×10^{-4}, although this changes with temperature. It is evident that some deviations from this value occurred, indicating certain inaccuracies in reading the humidity chart.

The values of m_{SO_2} calculated by equation (7) can be subject to considerable error for only small errors in the values of humidity. This is because the calculation involves the difference between two numbers which do not differ greatly in size. Thus, a small error in one or both can result in a large error in their difference. To minimize these errors as much as possible, the values of H_w were determined from tables of thermodynamic properties of moist air (*5*), while values of H_a were determined from an accurately constructed humidity chart. Significant inconsistencies in the values of the

slopes so calculated were then presumed due largely to experimental errors; e.g., runs 17, 18 and 19.

It should be noted that on the humidity chart used to obtain H_a the so-called wet-bulb lines are actually lines of adiabatic saturation calculated from the expression

$$\left(\frac{H_s - H_a}{t_a - t_s}\right) = c_s/\lambda_s \qquad (8)$$

where

H_s = the humidity corresponding to adiabatic saturation
H_a = humidity of air corresponding to temperatures t_a and t_s
t_a = air temperature
t_s = temperature of adiabatic saturation
c_s = humid heat of air = $0.24 + 0.45\ H_a$
λ_s = latent heat of evaporation corresponding to t_s

Equation (8) is suitable for estimating humidity for air-water vapor systems from wet-bulb temperature measurements by virtue of the fortuitous fact that

$$c_s/\lambda_s = (h_c/k'_g)/\lambda_s \qquad (9)$$

or

$$h_c/k'_g = c_s \qquad (10)$$

This is not true, however, for other vapor-air systems.

Equation (8) shows that the adiabatic saturation lines are not exactly linear because c_s varies with H_a while λ_s remains constant at the adiabatic saturation temperature. Hence, the adiabatic lines show a slight curvature and are concave upward. Further, even though they are approximated by a secant line, the slope of such lines will decrease 10% in going from wet-bulb temperatures of 70 to 130°F. Therefore, in comparing the slopes of the wet-bulb lines for air-water vapor-sulfur dioxide systems with air-water vapor only, all of these facts must be kept in mind.

Based on the experimental data obtained so far in this study, a humidity chart for one atmosphere total pressure was drawn, Fig. 8, for air sulfur dioxide-water vapor systems in which wet-bulb lines are shown with slopes which are about 10% steeper than for air-water vapor only. These lines also follow the curvature of the adiabatic saturation lines for air-water vapor. This chart is recommended only for the temperature and humidity ranges indicated. The saturation line in this chart is calculated from the vapor pressure for pure water because sulfur dioxide has a negligible influence on the vapor pressure of water for the concentrations involved.

Figure 8 should be considered tentative at this time and subject to further revision as additional data become available. However, it should permit one to estimate the humidity of sulfur dioxide-containing gases by means of wet-bulb thermometry with 10% accuracy. Linear interpolation between the sulfur dioxide lines and air-water vapor only lines for sulfur dioxide contents of less than 20 mole % is probably justifiable. An interpretation of the meaning of the sulfur dioxide wet-bulb lines is given in the discussion which follows.

DISCUSSION

The basic phenomenon involved in this study is one of simultaneous heat and mass transfer with absorption of sulfur dioxide on the wet bulb. The system is unique in that it involves three gaseous components in contrast to the usual binary system, plus the fact that one component, sulfur dioxide, is soluble in the water on the wet-bulb thermometer. This makes the prediction of the heat and mass transfer coefficients by rigorous procedures somewhat difficult, first, because of the complexities in estimating values of diffusivity, thermal conductivity, and viscosity for substitution in equation (4), and, second, because of ignorance concerning the true picture of the diffusion mechanism for all

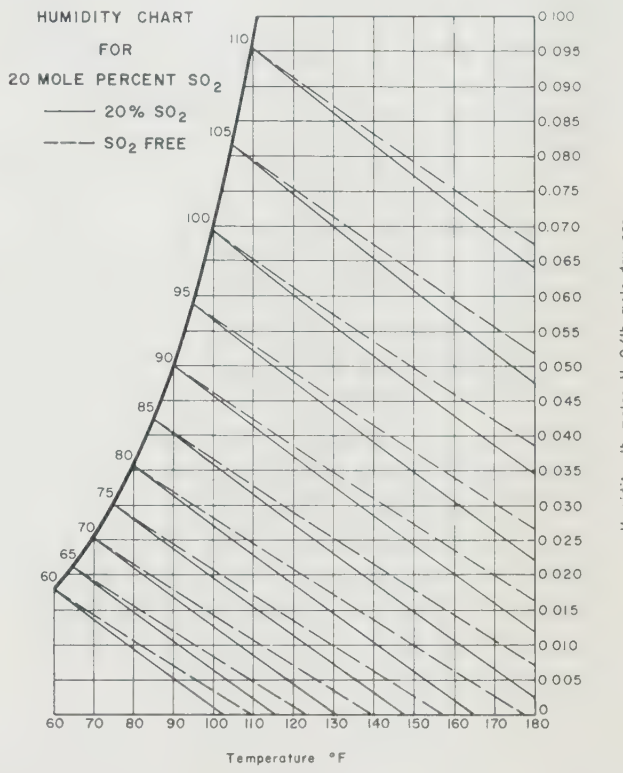

Fig. 8

components. There are few experimental data on diffusivities in multicomponent systems.

Methods of computing diffusion coefficients for multicomponent systems have been proposed by Bird *et al.* (*2*) and by Wilke (*10*). The Wilke procedure involves a fairly simple calculation for the case of diffusion of one component into two nondiffusing components. In this procedure the binary diffusion coefficients are averaged according to the mole fraction of each gas present as given by the following equation for a three-component system:

$$D_{vm} = \frac{(1 - y_v)}{y_{SO_2}/D_{vSO_2} + y_a/D_{va}} \qquad (11)$$

where

D_{vm} = mean diffusion coefficient for water vapor in sulfur dioxide and air
D_{vSO_2} = diffusion coefficient for water vapor in sulfur dioxide
D_{va} = diffusion coefficient for water vapor in air
y_v, y_a, y_{SO_2} = arithmetic average mole fractions of water vapor, air, and sulfur dioxide, respectively, in the gas film surrounding the wet bulb

As a first approximation it can be assumed that water vapor is the only diffusing component and that

sulfur dioxide and air are nondiffusing. This may be nearly true if the water on the wet-bulb wick is saturated with sulfur dioxide. Further, for water so saturated at the wet-bulb temperatures considered in this investigation, there is negligible vapor pressure reduction caused by the sulfur dioxide.

Figure 2 gives values of D_{va} and $D_{v\mathrm{SO}_2}$ as functions of temperature as computed by Heubner (*6*) according to procedures proposed by Bird *et al.* (*2*).

According to the semitheoretical equation of Chilton and Colburn (*3*), equation (4), the psychrometric ratio for air sulfur dioxide-water should be predictable from values of the transport properties. The following calculation of h_c/k'_g illustrates the use of equation (4) to estimate the slopes of the wet-bulb lines.

Example of Prediction of h_c/k''_g, for Conditions of Run 11

In computing values of thermal conductivity, diffusivity, density, and specific heat of the film surrounding the wet bulb, arithmetic average film conditions are assumed.

1. Wet-bulb temperature, $t_w = 85.8$°F.
2. Dry-bulb temperature, $t_a = 104.5$°F.
3. Average water vapor pressure across film = 1.143 in. Hg
4. Average pressure of stagnant gases = 28.76 in. Hg
5. $y_v = 0.0382$; $y_{\mathrm{SO}_2} = 0.192$; $y_a = 0.77$; and $(1 - y_v) = 0.9618$
6. From Fig. 2, $D_{v\mathrm{SO}_2} = 0.6$ sq. ft. per hr. and $D_{va} = 1.00$ sq. ft. per hr. at 100°F., average film temperature
7. $D_{vm} = 0.9618/(0.19/0.6 + 0.77/1.00)$
   $= 0.9618/(0.32 + 0.77) = 0.9618/1.09$
   $= 0.875$ sq. ft. per hr.

This value is about 13% lower than for air-water vapor only.

Substitution of D_{vm} and average values of the other transport properties in equation (4) gives

$$h_c/k'_g = c_s\,(0.013/(0.875)(0.102)(0.21)^{2/3} = 0.782c_s$$

The humid heat, c_s, must be computed, taking into account the presence of sulfur dioxide. Thus,

$$c_s = \frac{6.95(1 - y) + 10.1y}{29(1 - y) + 64y} + 0.45H \qquad (12)$$

where y = mole fraction of sulfur dioxide. For 20 mole % SO_2,

$$c_s = 0.21 + 0.45H \qquad (13)$$

and for the conditions considered, $H = 0.0175$ on a pound basis. Thus,

$$c_s = 0.21 + 0.45 \times 0.0175 = 0.218$$

Accordingly,

$$h_c/k'_g = 0.782 \times 0.218 = 0.171 \text{ B.t.u. per (lb.)(°F.)}$$

For 20 mole % SO_2, the slope of the wet-bulb lines would be estimated as

$$h_c/\lambda_w k''_g = (M_g/M_v)h_c/\lambda_w k'_g = 2.0 \times 0.171/1032 = 0.00032$$

This value is substantially lower than the value of 0.00045 obtained from the experimental data. One explanation for this discrepancy, however, might be found in the heat effects resulting from sulfur dioxide absorption on the wet bulb. Thus, a heat balance incorporating this effect gives

$$\frac{h_c}{k'_g} = (\lambda_w - Q)(H_w - H_a)/(t_a - t_w) \qquad (14)$$

where

Q = heat evolved per pound of water evaporated from the wet bulb, B.t.u. per lb.

The slope of the wet-bulb lines is then expressed by

$$m_{\mathrm{SO}_2} = h_c/k'_g(\lambda_w - Q) \qquad (15)$$

and Q must be properly evaluated. The heat effect can be assumed to be caused essentially by the heat of solution of sulfur dioxide in fresh water coming to the wick, at the same rate as the rate of evaporation. If it is assumed that the water on the wick is kept saturated with sulfur dioxide and in equilibrium with the sulfur dioxide in the air stream, then

$$Q = x\Delta H_s \qquad (16)$$

where x = concentration of sulfur dioxide in the water, weight per cent, and ΔH_s = heat of solution corresponding to the concentration x.

For 20 mole % SO_2 in air, the corresponding saturation concentration of sulfur dioxide in water is about 2.5%. Thus, $Q = 0.025\ \Delta H_s$, and from the paper by Plummer (*8*), $\Delta H_s = 210$ B.t.u. per lb. SO_2 absorbed. Hence, $Q = 210 \times 0.025 = 5.25$ B.t.u. per lb., and $(\lambda_w - Q) = \lambda_w - 5.25$. The heat of absorption, therefore, can be considered as a negligible effect, since λ_w is on the order of 1000.

It appears, then that a better theoretical prediction of the slopes of the wet-bulb lines when sulfur dioxide is present, will require a closer inspection of the diffusion mechanism. Thus, a lower value of D_{vm} would produce agreement between theory and the experimental results. A lower value might occur if sulfur dioxide were treated as a diffusing rather than nondiffusing component, and presumably there is some diffusion of sulfur dioxide both toward and away from the wet bulb. However, the exact mechanism is complex.

A comparison of the data obtained in this study with adiabatic saturation theory is briefly instructive. The equation for the adiabatic saturation line, equation (8), can be modified for the presence of sulfur dioxide by incorporating equation (12) in the humid heat term. When this is done for 20 mole % SO_2, the following expression for the slope of the adiabatic saturation lines is obtained:

$$\frac{H_s - H_a}{t_a - t_s} = \frac{c_s}{\lambda_s} = \frac{7.42 + 8.04H}{\lambda_s} \qquad (17)$$

where c_s and λ_s are now expressed an a mole basis. Slopes were computed from equation (17) for the conditions corresponding to the experimental tests and these have been tabulated in Table II for comparison with the experimental values. It is evident that better agreement exists with the slopes for adiabatic saturation curves than those calculated from a simple diffusion theory.

A possible use of precise experimental wet-bulb temperatures in multicomponent systems might be a "reverse" calculation, in which the psychrometric ratio is used to compute average diffusion coefficients. Thus, from equation (4)

$$D_{vm} = \frac{k_f}{\rho c_p}\left(\frac{c_s k'_g}{h_c}\right)^{2/3} \qquad (18)$$

The term in parentheses is determined from the experimental measurements of wet-bulb temperatures in multicomponent systems. The data reported in this paper, however, are believed to be too inaccurate to use in equation (18). More precise data can be obtained by measuring the air humidity by an analytical procedure, such as absorption and gravimetric analysis, rather than by the wet-bulb temperature method used in this study. In spite of the inaccuracies of the measurements in this study, presumably the values of the psychrometric ratio would permit an order-of-magnitude estimate of D_{vm} by Equation (18), if such an estimate were essential for some process design calculation. Thus, a value for D_{vm} from the data of run no. 11 is estimated to be 0.371 sq. ft. per hr. instead of a value of 0.875 calculated from equation (4).

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Unsteady Flow Due to Wire Shake

ARIS C. SPENGOS

Considerable insight into the effectiveness of wire shake can be obtained from the analysis of flow of a Newtonian fluid bounded by a plane which is subjected to linear harmonic oscillations in its own plane. The differential system defining the unsteady fluid motion, induced by the boundary oscillations, and its solution is discussed in this note. The relative importance of some of the variables involved in the problem of wire shake becomes apparent from the simplified analysis. The effect of these variables on shake intensity is discussed and compared with previous experimental results.

A recent extensive review of literature on the subject of wire shake of a fourdrinier paper machine published by Judt (*1*) reveals that most of the available information describes experimental observations of the apparent effect of shake on paper quality, fiber orientation, and drainage. Judt also points out that contradictory statements about the effect of shake are frequently encountered in technical literature. He attributes this to lack of information describing in detail the experimental conditions.

An analytical investigation of the oscillatory motion of the stock, although very desirable, is rather difficult to carry out because of the complexity introduced when drainage and viscosity changes along the wire are considered. However, considerable insight into the problem can be obtained from the analysis of the motion of a fluid which is bounded by an oscillating plane. Such an analysis is based on certain simplifying assumptions and the obtained results are useful only in that they point out the relative importance of some of the variables involved.

It is obvious that because of the oscillatory motion of the wire in the cross-machine direction, the motion of the stock in this direction is unsteady. Also, since intentionally oscillating headboxes are rare, a certain time interval is required for the full establishment of the flow. In the solution of the equation defining the fluid motion over an oscillating boundary (to be discussed in this note), the unsteadiness of the flow, the rate at which the fluid motion decreases with depth, the phase lag with respect to the motion of the boundary, and the relative importance of the time required for the flow establishment become apparent.

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FLOW OVER AN OSCILLATING BOUNDARY

It is assumed that the solid plane boundary on which a viscous incompressible fluid lies is very large, and that the boundary is subjected to linear harmonic oscillations in its own plane. The y-axis is taken in the direction of the oscillations (cross-machine direction), the x-axis in the plane of the boundary and perpendicular to the y-axis (machine direction), and the z-axis perpendicular to the plane of the boundary. The fluid is assumed to extend over the entire boundary and its depth, in the positive z direction, is large. For a Newtonian fluid, the differential equation defining the motion of the fluid (*2*) due to the boundary oscillations is:

$$\frac{\partial v}{\partial t} = \nu \frac{\partial^2 v}{\partial z^2} \qquad (1)$$

in which v is the velocity in the y direction, t is time, and ν the kinematic viscosity. Equation (1) is obtained from the Navier-Stokes equations after simplifications which are based on the assumptions that the velocities in the other two directions, x and z, are zero, and that the fluid pressure is constant. Thus, equation (1) can be interpreted as expressing the interaction of the friction forces with the local acceleration since the convective acceleration terms in the Navier-Stokes equation vanish.

The initial and boundary conditions to be considered along with equation (1) are:

$$v = 0, \qquad \text{for } z \geq 0, \text{ at } t = 0 \qquad (2)$$

which states that the motion of the fluid starts from rest, and:

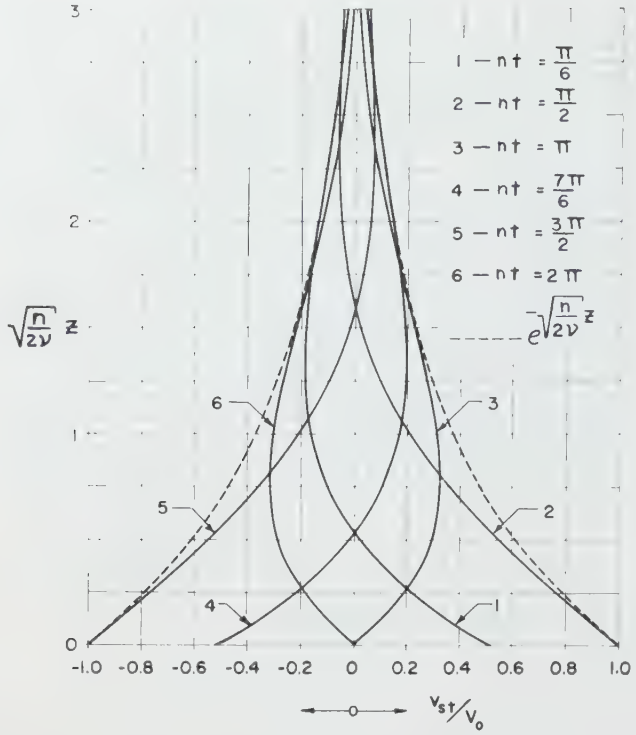

Fig. 1. Variation of steady state velocity with dimensionless fluid depth, for different values of nt, and envelopes of maximum velocity

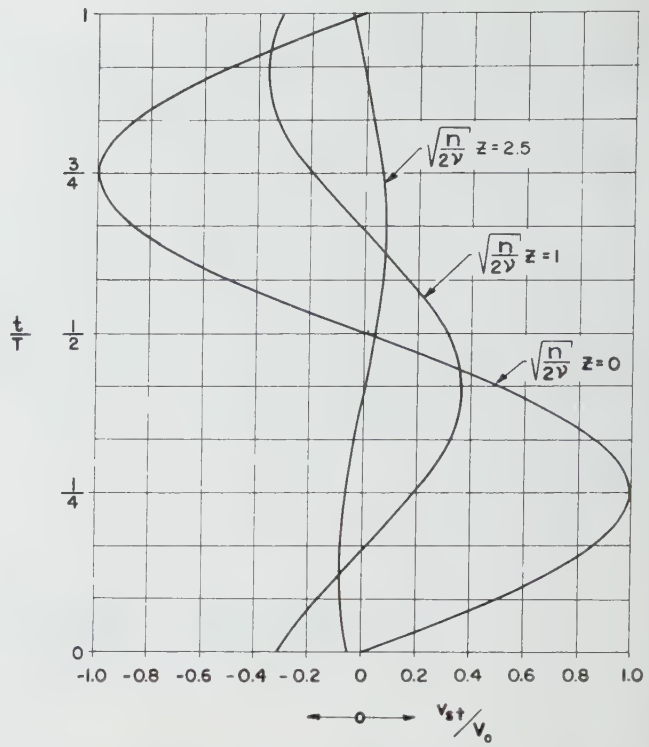

Fig. 2. Variation of steady state velocity with boundary oscillations at different dimensionless fluid depths

$$v(0, t) = V_0 \sin nt, \qquad \text{for } z = 0 \qquad (3)$$

which imposes the conditions that there is no slip between the fluid and the solid boundary at the contact surface, and that the velocity variations of the boundary are sinusoidal. In equation (3), V_0 is the maximum velocity of the boundary, and $n = 2\pi f$, where f is the frequency of oscillations.

The solution of the differential system comprised of equations (1), (2), and (3) is known from the solution of the equation of linear motion of heat (*3*) which has the same form as equation (1). For the case under consideration, the total velocity, v_T, of the fluid which extends over the oscillating boundary is:

$$v_T(z, t) = V_0 e^{-\sqrt{\frac{n}{2\nu}}z} \sin\left(nt - \sqrt{\frac{n}{2\nu}}z\right) + \frac{2\nu V_0}{\pi}\int_0^\infty \frac{n\theta}{n^2 + \nu^2\theta^4} e^{-\nu t\theta^2} \sin z\theta \, d\theta \qquad (4)$$

Equation (4) satifies both equation (1) and the initial and boundary conditions, equations (2) and (3), and it has been obtained from the corresponding case of temperature distribution in a solid with its surface temperature harmonically varied (*3*).

The first term on the right-hand side of equation (4) is what usually is referred to as the steady state term of the solution and it will be indicated by v_{st}. The time dependency of this term points out the unsteady nature of the fluid motion. The second term is the transient term and it will be indicated by v_{tr}. In the transient term, θ is the variable of integration and has the dimension $1/L$, and t denotes time so that for large values of $t(t \to \infty)$ the transient term dies out.

In Fig. 1 the steady state term of equation (4) has been plotted in a dimensionless form, (v_{st}/V_0), for various instances of time. The ordinate of this plot, $\sqrt{n/2\nu}\, z$, can be considered as dimensionless indication of the distance from the plane boundary into the fluid.

It is clearly seen from the velocity profiles in this plot, as well as from the steady state term of equation (4), that the harmonic oscillations of the fluid velocity decrease exponentially. The dashed curve in the plot is the envelope of the maximum velocity points that occur at various depths. Also, the phase lag, $\sqrt{n/2\nu}\, z$, with respect to the motion of the boundary is obvious; the distance between two fluid layers that oscillate in phase is $z = 2\pi\sqrt{2\nu/n}$. This distance, when measured from the oscillating boundary, can be arbitrarily defined as the depth of penetration of the fluid motion. The maximum velocity of an oscillating fluid layer at this depth is about 0.2% of the maximum velocity of the boundary.

In Fig. 2 the steady state velocity term has been plotted for various dimensionless distances from the plane boundary. The ordinate of this plot, t/T, indicates the number of oscillations since t is time and $T = 1/f$ is the period of oscillations. This plot, impressively illustrates the fast damping of the velocity variations, as well as the phase lag with respect to the boundary oscillations.

Figure 3 is a dimensional plot indicating the relative effect on the steady state velocity profiles, for $nt = \pi/2$, of (a) variations of fluid viscosity, and (b) variations of frequency of the boundary oscillations. The ordinate is the distance from the boundary in thousandths of an inch, and the viscosity ν_0 is that of water at 78°F. (0.96×10^{-5} ft.^{2} per sec.). Velocity profiles for fluids with viscosities 10 to 50 times larger than that of water have been plotted. The latter value corresponds to the apparent viscosity of a stock of 1.5% consistency. The range of frequencies is that commonly encountered in wire shake practice. The maximum velocity envelopes for the three values of viscosities are also plotted in the same figure; the frequency for these envelopes is 4 c.p.s. To avoid

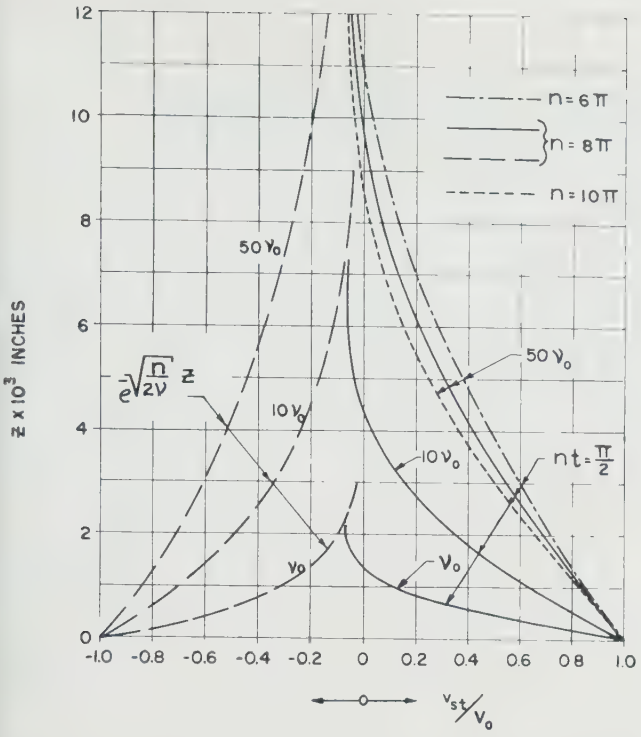

Fig. 3. Variation of steady state velocity with fluid depth, and envelopes of maximum velocity, for different viscosities and frequencies of boundary oscillations

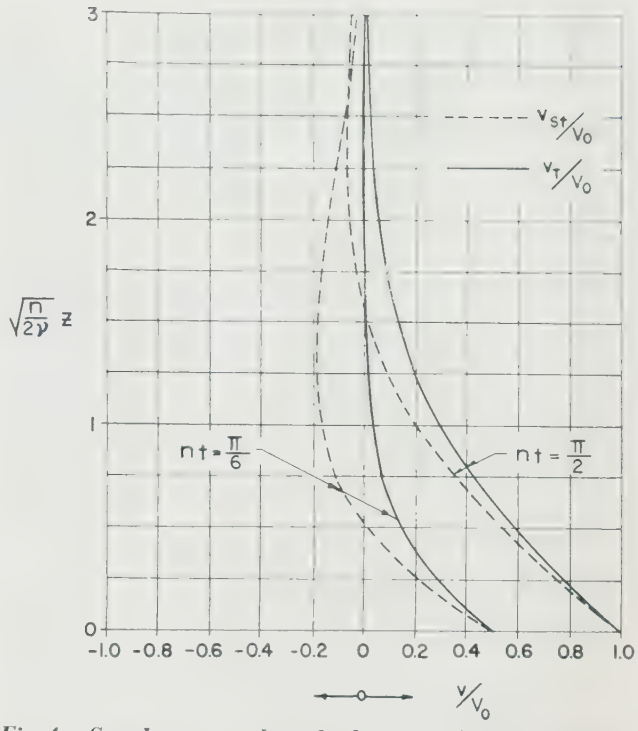

Fig. 4. Steady state and total velocity profiles, for different values of nt, indicating effect of transient term ($v_{tr} = v_T - v_{st}$)

congestion, only the negative velocity envelopes have been plotted.

The transient term, v_{tr}, of equation (4) is given in an integral form because of the obvious difficulty in carrying out the integration. In fact, it is an improper integral and therefore its integration cannot be carried out with formal methods. Expanding the integrand in series does not alleviate the integration difficulties. Instead, the evaluation of this term was done by numerical integration. The value of the integral was obtained using Simpson's Rule and a digital computer. The Royal McBee LGP-30 Computer, of the Scott Paper Co. Research Division, was used. It was also with such numerical integration that the transient term was found to satisfy the initial condition as stated by equation (2).

When that the boundary oscillations are a cosine function, the transient term is the following (*3*):

$$v_{tr} = -\frac{2\nu V_0}{\pi}\int_0^\infty \frac{\nu\theta^3}{n^2 + \nu^2\theta^4}\, e^{-\nu t\theta^2} \sin z\theta \, d\theta \qquad (5)$$

Formal integration of this integral is also impossible.

Figure 4 shows the relative magnitude of the transient term for two particular values of nt. The profiles for the total velocity, v_T, and the steady state component, v_{st}, are plotted using the previously mentioned dimensionless arrangement of the variables. The validity of such dimensionless presentation of the effect of the transient term was checked by numerical integration of this term for various values of viscosities and frequencies and it was found to be within the accuracy of the numerical integration. The largest values of the transient term occur, of course, at $t = 0$, and are numerically equal to those given in Fig. 1 for $nt = \pi$. For $nt = \pi/2$ the largest value of the transient term, $v_{tr} = v_T - v_{st}$, is about $^1/_3$ of that at $t = 0$, thus indicating the relatively fast decay of this term of the total velocity of the fluid.

The shear stress τ at any particular point and instance is, for the steady state condition:

$$\tau = \mu \frac{d(v_{st})}{dz} \qquad (6)$$

in which μ is the dynamic viscosity of the fluid. Differentiation of the steady state term of equation (4) and substitution in equation (6) yields:

$$\tau = -\mu V_0 \sqrt{\frac{n}{2\nu}}\, e^{-\sqrt{\frac{n}{2\nu}}z}\left[\sin\left(nt - \sqrt{\frac{n}{2\nu}}\, z\right) + \cos\left(nt - \sqrt{\frac{n}{2\nu}}\, z\right)\right] \qquad (7)$$

After simplification, equation (7) can be written as:

$$\tau = -\mu V_0 \sqrt{\frac{n}{\nu}}\, e^{-\sqrt{\frac{n}{2\nu}}z} \cos\left(nt - \sqrt{\frac{n}{2\nu}}\, z + \frac{\pi}{4}\right) \qquad (8)$$

Equation (8) indicates the exponential decrease of shear stress as the distance from the boundary increases, and that the maximum shear stress occurs on the boundary ($z = 0$) at intervals of one-half of a cycle after the first maximum which occurs at $nt = {}^{3\pi}/_4$. The minima which are $\tau = 0$, occur also at intervals of one-half of a cycle after the first minimum which occurs at $nt = \pi/4$.

DISCUSSION

In the analysis of flow over an oscillating boundary, discussed above, the effect of drainage, the rheological properties of the stock (*4*, *5*), and the finite magnitude of the fluid velocity in the x-direction (machine direction), all of which are encountered in the fourdrinier wire shake, were not taken into consideration. Of these omissions, the first two can be considered as affecting primarily the viscosity of the fluid. Thus, instead of a constant viscosity, characterizing a Newtonian fluid, the value of ν in equation (1) is actually, in the case of stock on a wire, a function of z,

the coordinate along the depth of stock, and of time, since the stock and wire travel with the same speed in the machine direction. If the variation of viscosity with position and time is to be considered in equation (1), this equation becomes more difficult to solve. Its solution could be possibly obtained by using numerical methods, such as finite differences, and a digital computer.

As for the third omission, the velocity in the machine direction, it is less important than the other two because the stock and the wire travel approximately at the same speed and consequently $u = U$, in which U is constant and equal to the wire speed. Thus, using this velocity, time can be expressed as $t = x/U$, where x is the distance from the slice to a particular position along the wire.

Considering the above limitations of the analysis discussed in the previous section, certain remarks can be made concerning the relative importance of some of the variables involved in the wire shake problem. Inspection of equation (4), for the velocity variations within the fluid subjected to shake, and equation (8), for the variations of the shear stress, indicates that both are proportional to the maximum velocity of the oscillating boundary. If the oscillations of the boundary are assumed to be

$$y = -Y_0 \cos nt \tag{9}$$

in which Y_0 is the amplitude of the boundary oscillations, the velocity variations are:

$$V = \frac{dy}{dt} = Y_0 n \sin nt \tag{10}$$

Considering the boundary conditions given by equation (3), the maximum velocity is:

$$V_0 = Y_0 n \tag{11}$$

Equation (11) indicates that V_0 is proportional to the product of the amplitude and frequency of oscillations since $n = 2\pi f$.

If V_0 is considered to indicate shake intensity, and consequently effectiveness of shake in improving paper quality, it is clearly seen from equation (11) that increasing this product will increase the effectiveness of shake. This agrees well with experimental evidence obtained by Lindberg and discussed by Judt (*1*) in his review. Lindberg has observed that with increasing intensity the favorable effect on sheet formation first increases rapidly, and then the effect gradually decreases. An explanation of the gradual decrease can be obtained from an examination of the damping factor, $\exp(-\sqrt{n/2\nu}\, z)$, in equations (4) and (8). increasing the frequency, and consequently n, reduces the depth of penetration of fluid motion. This is illustrated in Fig. 3 where velocity profiles for the same fluid, for frequencies 3, 4, and 5 cycles per second, and for $nt = \pi/2$ have been plotted.

It is well known that with increasing machine speeds the effectiveness of shake in improving sheet formation diminishes. In his experimental investigation, Judt (1) found that under the most favorable conditions the shake effect at a machine speed of 525 f.p.m. was negligible. In examining equations (*4*) and (8) for machine speed effect the variable to be considered is undoubtedly time, since $t = x/U$, where x is the distance along the wire, and U the wire speed. For increasing speeds and a given position along the wire the time length during which the stock is subjected to shake decreases. When the time interval is small, the transient term in equation (4) is appreciable; in Fig. 4 its effect is indicated at two instances during the first one-fourth of a cycle of the shake oscillations. After the transient term dies out, the number of times the stock will be subjected to maximum shear stress will depend on the length of the time interval. Equation (8) indicates that the maximum shear stress occurs twice during one cycle of oscillation. Therefore, considering the shear stress action as an important factor in obtaining uniform formation, its effectiveness decreases with shorter time lengths and, therefore, high machine speeds. Likewise the number of times that the velocity profiles will undergo their cyclic changes, as indicated in Figs. 1 and 2, will decrease.

The effect of viscosity of the stock on the effectiveness of the shake can be only broadly remarked upon in this discussion because of the limitations imposed in obtaining the solution of equation (1). However, it can be safely stated that the effect of shake increases with increasing viscosities. Figure 3 graphically illustrates the increasing depth of penetration of the shake with increasing values of viscosity. Also, the existence of a consistency gradient in the z-direction, from wire to stock surface might have a twofold effect. Firstly, this gradient could be interpreted as an apparent viscosity gradient, and therefore the solution of equation (1) would have to be modified to take this into consideration. Secondly, it is possible to consider a situation in which the lower part of the deposited mat firmly adheres to the wire and acts as one with it. Thus, as drainage proceeds the thickness of the adhering mat increases in the z-direction until it comes close to the free surface. This could possibly be interpreted as a means of enhancing the depth of penetration. Undoubtedly, the penetration of shake into the fluid layer is accomplished through viscous shear, consequently, whatever the viscous properties of the fluid may be, Newtonian or non-Newtonian, its viscosity is of paramount importance in successfully imparting to it an oscillatory motion.

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Lignins and the Mechanism of Lignification

WALTER J. SCHUBERT and F. F. NORD

The importance of the phenylpropane carbon structure as an integral part of the constitution of lignin is generally acknowledged. Hence, the probability of the origin of lignin from carbohydrate as its ultimate source suggests the possibility of a relationship between the formation of lignin and the biogenesis of the phenylpropane-derived aromatic amino acids, phenylalanine and tyrosine. Since the biochemical conversion of carbohydrates into these aromatic amino acids has been established as proceeding by way of shikimic and *p*-hydroxyphenylpyruvic acids, it was considered that these intermediates might play a part in lignification as well. This was demonstrated to be the case as the result of investigations in which radioactively labeled intermediates were fed to growing plants and trees. Recent results, involving the feeding of labeled samples of D-glucose to Norway spruce trees, provide evidence that glucose is the carbohydrate precursor of lignin. Considering the central place that D-glucose occupies in plant biochemistry, it is significant that the plant also possesses the enzymes necessary to convert this monosaccharide into lignin as well. Present knowledge of the lignification process may be expressed as follows: carbon dioxide → carbohydrate (glucose) → shikimic acid → *p*-hydroxyphenylpyruvic acid → primary lignin building stones → secondary lignin building stones → lignin.

FROM THE viewpoint of the plant physiologist, the chemistry of wood is a special case of the utilization by plants of the carbon absorbed from the atmosphere as carbon dioxide. But for the wood chemist, this raw material represents a difficult and intriguing substance: difficult, because the components of which wood is comprised are very complex; intriguing, because about one-half of the substance of wood has proved extremely difficult to exploit chemically on a scale comparable with that of the manufacture of paper.

When softwoods are subjected to the pulping process for paper manufacture, approximately one-half of the wood is dissolved. Of the dissolved material, about one-half again consists of the aromatic polymer, lignin. It is the lignin which gives wood its rigidity, and it is precisely the lignin of wood which has resisted exploitation, but may, at some future time, provide the basic raw material for chemical utilization.

Ever since the studies of Falck (*1*) it has been generally agreed that there are two different types of wood decay brought about by fungi. These are the "brown" and "white" rots, and the difference between them is related to the changes which these rots effect on the chemical composition of the wood which is undergoing decay. In brown rot, the fungus selectively attacks the carbohydrate components of the decaying wood. But the lignin remains unaffected, and the decaying wood gradually turns brown in color. It may be noted that recently, the residual lignin remaining after decay by *Lenzites saepiaria* has been reported (*2*) to be somewhat demethylated; but this may be a unique case. On the other hand, in white rot, the lignin seems to be the main substrate of the fungus. In decaying wood of this type, one can detect patches of a white substance which has been considered to be almost pure cellulose.

Some years ago, it occurred to the present authors that advantage could be taken of the selective ability of the brown-rot fungi to remove the cellulose from wood, thereby possibly freeing the lignin present in association with it, in an attempt eventually to isolate chemically unchanged lignin from the partially decayed wood.

Table I. The Yields of Lignin Isolated from Sound and from Decayed White Scots Pinewood

Period of decay, months	*Organism*	*Lignin yield, % of total*
0	.....	3.2
13	*Lenzites sepiaria*	18.3
15	*Poria vaillantii*	22.7

Briefly, the method of attack was as follows. Sound wood was first ground to sawdust and subjected to sterilization. Then this sterile sawdust was inoculated with a wood-destroying fungus known to produce brown rot. The progress of the decay of the wood was followed by periodic analyses of the decaying sawdust. Since the organism used was of the brown rot type, the percentage of cellulose would gradually diminish, while the relative content of lignin would concomitantly increase. This should have the effect of rendering the lignin more soluble in ethyl alcohol than it was prior to the fungal decay, and consequently, should allow the removal of greater amounts of lignin by extraction with this solvent.

This approach was first attempted by subjecting two different species of softwoods, namely, white Scots pine and white fir, to the decaying effects of four species of brown rot fungi (*3*).

Sound, white Scots pine, before fungal decay, yields 3.2% of its lignin as "native lignin" by extraction with

Table II. A Comparison of the "Native" and Enzymically Liberated Lignins of White Scots Pinewood

Properties	*"Native lignin"*	*Enzymically liberated lignin*
C, %	64.0	64.2
H, %	6.3	6.0
OCH_3, %	14.5	14.4
OCH_3 of acetate, %	10.1	10.2
OCH_3 of phenylhydrazone, %	13.3	13.4
Soluble in:	EtOH, MeOH, dioxane, pyridine, 4% NaOH, gl. HOAc	Same
Insoluble in:	Water, ether, benzene, petr. ether	Same
Reducing ability	Reduces Fehling's solution	Same
Color reaction with:		
Phloroglucinol	Red-violet	Same
Aniline	Yellow	
p-Phenylenediamine	Yellow	Same
Diphenylamine	Yellow	

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Table III. A Comparison of the "Native" (NL) and Enzymically Liberated (EL) Hardwood Lignins

Properties	Oak		Birch		Maple	
	NL	EL	NL	EL	NL	EL
C, %	58.6	58.4	61.4	61.6	61.0	61.3
H, %	5.3	5.2	5.5	5.6	5.6	5.5
OCH_3, %	14.8	14.6	14.9	14.8	17.4	17.8
OCH_3 of phenylhydrazone, %	13.7	13.6	13.1	13.4	15.5	15.8
OCH_3 of acetate, %	10.2	10.3	10.0	10.4	12.8	12.9
OCH_3 of CH_2N_2-methylated lignin, %	25.0	24.8	26.0	25.8	23.6	23.9
Oxidation of lignin:						
Vanillin, %	21.3	20.9	18.6	19.1	17.2	16.9
Syringaldehyde, %	Nil	Nil	Nil	Nil	4.5	4.2

ethyl alcohol. In one experiment of the type described, after decaying this wood with *Poria vaillantii* for 15 months, 22.7% of the lignin was isolated by alcohol extraction (*4*). The authors refer to their lignin obtained in this way as "enzymically liberated lignin" (*5*). (see Tables I–III)

We were curious to learn whether enzymically liberated lignin was the same as, or different from, the "native lignin" isolated by Brauns (*6*). Accordingly, we isolated lignin from white Scots pine by both methods and made an exhaustive comparison of the two preparations. As the result of this comparison, and as far as could be determined, the "native" and enzymically liberated lignins of white Scots pine were very similar.

We then considered the possibility that the lignin isolated from white Scots pine might represent a uniform chemical entity which could be constant for other species of softwoods. Accordingly, a similar comparison was made of the "native" and enzymically liberated lignins of white fir. From the results of this comparison, it appeared that the two lignins of this species were identical, and moreover, that both were very similar to the lignins of the white Scots pine. Hence, it appeared that these lignins might very well be characteristic for several species of softwoods (*3*, *4*).

In addition to these experiments on the softwoods, similar investigations were performed on the hardwoods oak, birch and maple, and on bagasse, the supporting fiber of the sugarcane plant. Comparisons of these lignin preparations revealed certain divergencies among the lignins of the various species, but they also revealed the identity of the "native lignin" of any one species to the enzymically liberated lignin of that species (*7*, *8*). (see Table IV)

Since the enzymically liberated lignins were found in all cases to be identical with the "native lignins," it would appear that the lignin of each species is a uniform chemical substance, or group of substances, the greater part of which is associated with the cellulose in such a way as to make impossible, or at least very difficult, its extraction from the sound wood by inert solvents, such as ethyl alcohol (*9*).

THE BIOGENESIS OF LIGNIN

Biochemists have long speculated about the mechanism by which plants are able to accomplish the feat of synthesizing benzenoid compounds from nonaromatic precursors. Nutritional and enzymic studies have resulted in the elaboration of a scheme for the origin of the aromatic amino acids, phenylalanine and tyrosine, from nonaromatic compounds (*10*). (see Fig. 1)

The probability of the origin of the aromatic polymer lignin from carbohydrate as its ultimate source then poses the possibility of a relationship between the lignification process and the aromatic amino acid biogenesis. The investigation of the biogenesis of lignin building stones in plants meets with experimental difficulty. However, studies on the biogenesis of the ester, methyl *p*-methoxycinnamate, formed by *Lentinus lepideus*, are somewhat simpler. Among the several species of wood-destroying fungi, *Lentinus lepideus* produces brown rot in wood. (see Fig. 2)

Table IV. A Chemical Comparison of the Lignins from Sound and from Decayed Bagasse

Properties	Sound	Decayed
C, %	61.5	61.6
H, %	5.7	5.9
OCH_3, %	15.3	15.4
OCH_3 of acetate, %	13.3	13.1
OCH_3 of phenylhydrazone, %	14.1	14.0
Oxidation products:		
Vanillin, %	17.8	17.3
Syringaldehyde, %	13.3	12.9
p-Hydroxybenzaldehyde, %	9.8	10.2

The metabolic processes associated with the decay of wood by this organism give rise to certain aromatic esters, namely, methyl anisate, methyl cinnamate, and methyl *p*-methoxycinnamate (*11*).

Earlier investigations had shown that it is possible to grow *Lentinus lepideus* on media containing glucose, xylose, or ethyl alcohol as sole carbon source, whereby methyl *p*-methoxy cinnamate appears as a crystalline deposit in the medium after several weeks of growth (*12*).

From this observation, it was concluded that methyl *p*-methoxycinnamate is not a product of the degrada-

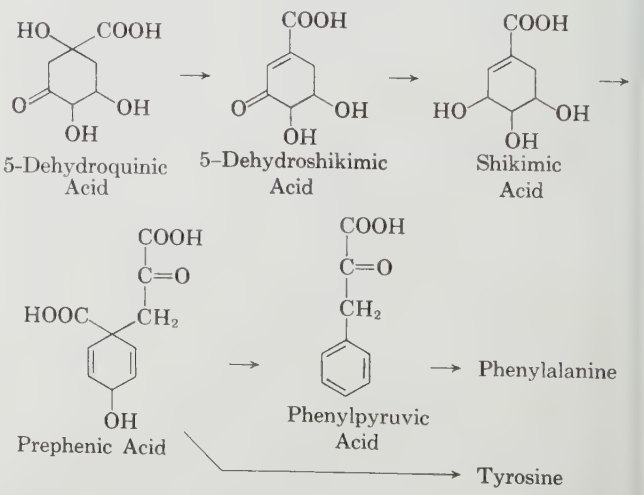
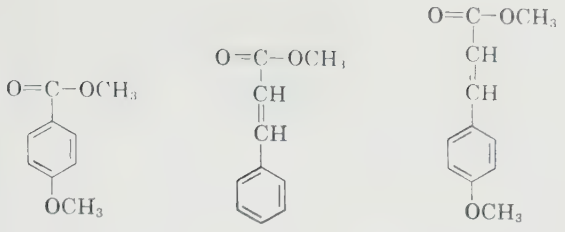


Fig. 1. Mechanism of the biogenesis of aromatic amino acids (10)



Methyl anisate (I) | Methyl cinnamate (II) | Methyl *p*-methoxy-cinnamate (III)

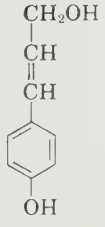
***Fig. 2. Metabolic products of* Lentinus lepideus**

tion of lignin, which might conceivably have been effected by the organism during its growth on wood, for *Lentinus lepideus* is capable of synthesizing this aromatic ester from carbohydrates or ethanol (*13*).

Results obtained from experiments on the biogenesis of methyl *p*-methoxycinnamate by *Lentinus lepideus* might then have importance in theorizing on the formation of lignin building stones, if we assume the existence of similar pathways in the formation of this ester and of the lignin building stones. This assumption is based on the structural similarity of methyl *p*-methoxycinnamate with *p*-hydroxycinnamyl alcohol, a building stone of lignin (*14*). (see Fig. 3)

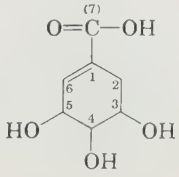
A series of nutritional, enzyme and tracer experiments were therefore undertaken, and the results of these studies revealed a definite biogenetic relationship between the formation of methyl *p*-methoxycinnamate and the biogenesis of the aromatic amino acids. The structural relationship between methyl *p*-methoxycinnamate and the lignin building stone *p*-hydroxycinnamyl alcohol has been mentioned. Hence, it seemed possible that lignin building stones are synthesized by a similar pathway. Thus, results obtained on the metabolism of *Lentinus lepideus* offered a means of investigating the problem of the biogenesis of the lignin building stones (*15*).

The mechanism of the biogenesis of lignin in living



p-Hydroxycinnamyl alcohol (IV)

Fig. 3. Lignin building stone



Position	Activity, % of total
2	43
6	52

Fig. 4. Distribution of activity in specifically labeled shikimic acid (10)

plants remained obscure until the discovery of the role of shikimic acid in the lignification process. Shikimic acid was found to function as an intermediate in the biogenesis from glucose of methyl *p*-methoxycinnamate by *Lentinus lepideus* (*14*). Since the biochemical conversion of carbohydrates into the aromatic amino acids also proceeds by way of the intermediate formation of shikimic acid (*10*), it was reasoned that this intermediate might likewise play a part in lignification as well. (see Fig 4)

The intervention of shikimic acid in the lignification process was demonstrated by the feeding of specifically labeled shikimic acid containing carbon-14 in positions 2 and 6 of its cyclohexene ring to growing sugarcane plants (*16*). The labeled shikimic acid was "force-fed" through the leaves of a growing sugarcane plant. Figure 5 illustrates the feeding technique. After several days of the feeding, the plant was cut down and its lignin isolated by a standard method. This lignin was found to be radioactive, and on oxidation, it yielded vanillin which retained the isotopic activity of the car-

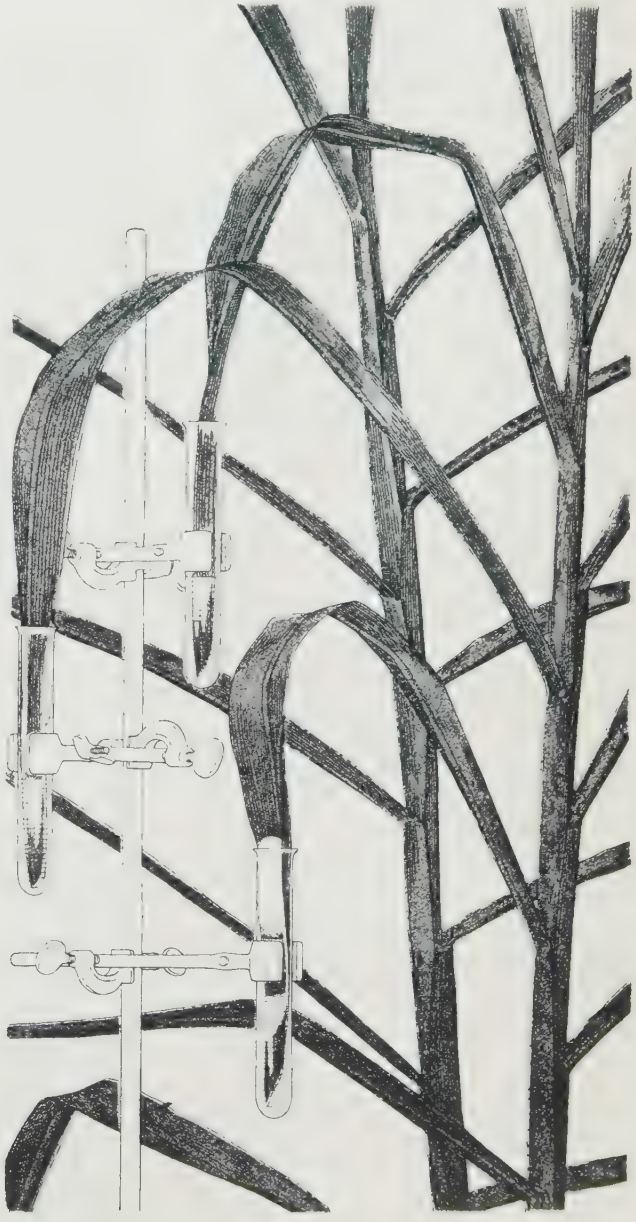


Fig. 5. Experimental method for incorporation of tagged compounds into sugarcane plants

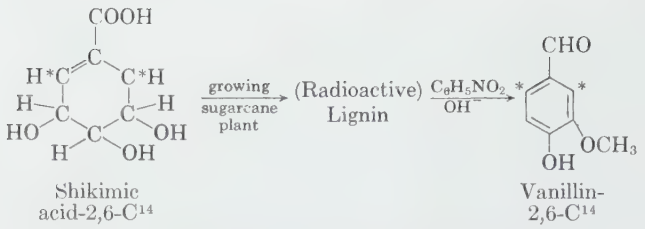


Fig. 6. Incorporation of specifically labeled shikimic acid into lignin by sugarcane plant

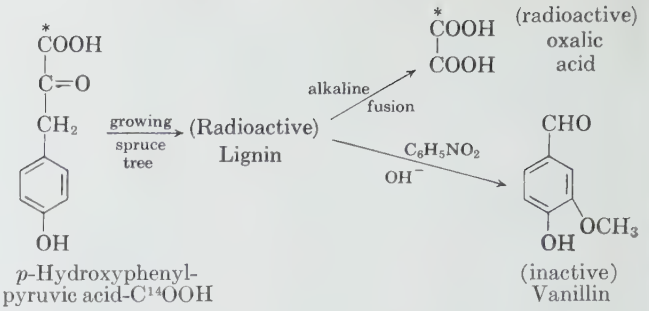


Fig. 7. Incorporation of specifically labeled p-hydroxyphenylpyruvic acid into lignin by spruce tree

bon-14 in the corresponding positions of its benzene ring. The retention of the integrity of the cyclohexene ring of shikimic acid during the course of its conversion into the benzene rings of lignin (see Fig. 6) represents direct evidence for the mediation of shikimic acid as an intermediate in the lignification process (*17*, *18*).

The implication of *p*-hydroxyphenylpyruvic acid in the biogenesis of methyl *p*-methoxycinnamate by *Lentinus lepideus* prompted an investigation of its possible function in lignification as well. Using the approach employed to demonstrate the intervention of shikimic acid in this process (see Fig. 7), *p*-hydroxyphenylpyruvic acid was found to serve as a precursor of lignin (*18*, *19*). The importance of the shikimic acid → *p*-hydroxyphenylpyruvic acid interconversion in lignification then posed the problem of the identity of the carbohydrate from which these lignin precursors are ultimately derived. Many conjectures have been made on the nature of the carbohydrate precursor; but most of these suggestions were purely speculative (*20*).

Table V. Distribution of Activities in the Plant Materials

Plant material	*Activities, counts/min./mg·C*		
	Uniformly labeled D-*Glucose-C*^{14}, *1 mc.*	D-*Glucose-1-C*^{14}, *1 mc.*	D-*Glucose-6-C*^{14}, *0.25 mc.*
Stem	460	1780	620
Lignin	240	770	200
Vanillin	..	40	50

In a preliminary experiment, uniformly carbon-14 labeled D-glucose was fed to a Norway spruce tree by immersing the needles at the ends of the upper branches of the tree into a solution of the radioactive glucose. After a period of metabolism, radioactivity was detected in the cambium layer of the tree. The lignin of this layer was isolated and found to be radioactive. Hence, the tree was able to convert glucose into lignin (*21*). (see Table V)

The fate of the glucose molecule during the process of lignification was then studied employing specifically labeled glucose-1-C^{14} and glucose-6-C^{14}. Each of the glucose samples was individually fed to Norway spruce trees in the manner already described. The lignin was again isolated from the cambium layer, and oxidized to vanillin. The distribution of the radioactivity in the carbon atoms of the vanillin was established according to a series of degradation reactions

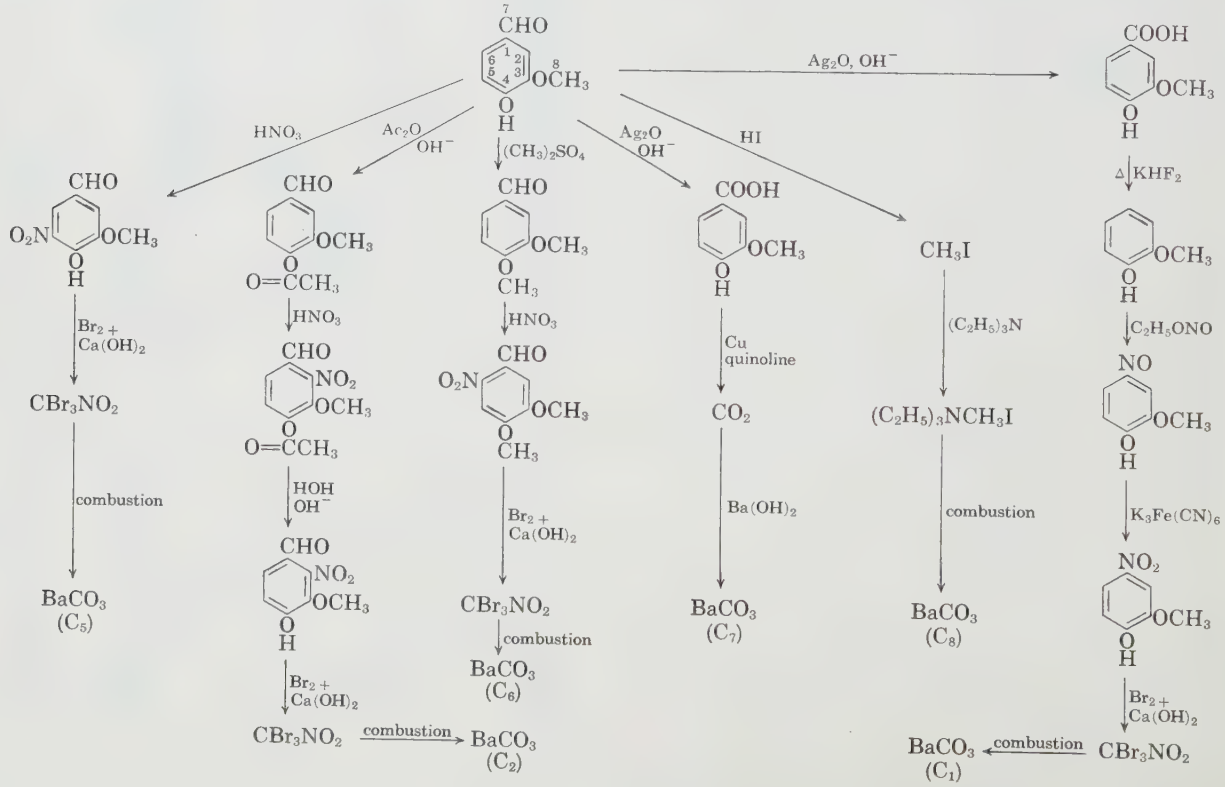


Fig. 8. Chemical degradation of vanillin

Table VI. Distribution of Activity in Vanillin Formed from D-Glucose-1-C^{14} and D-Glucose-6-C^{14}

Positions in vanillin	*D-Glucose 1-C^{14}, counts /min./mm. C*	*1 mc. Vanillin, %*	*Glucose 6-C^{14}, counts /min./mm. C*	*0.25 mc. Vanillin, %*
Vanillin	3850	100.0	4850	100.0
Carbon-1	100	2.6	220	4.5
Carbon-2	700	18.2	780	16.1
Carbon-5	120	3.1	160	3.9
Carbon-6	440	11.4	880	18.1
Carbon-7	1100	28.5	1070	22.0
Carbon-8	1200	31.1	1200	24.7
Carbon-3, 4[a]	...	5.1	...	10.7

[a] Calculated values.

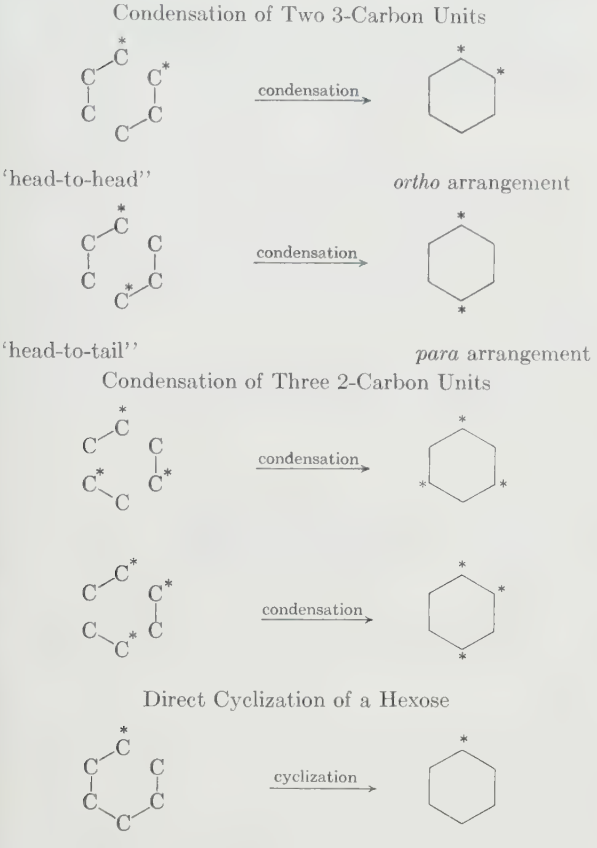


Fig. 9. Mechanisms of cyclization

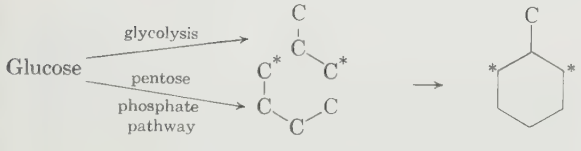


Fig. 10. Cyclization from glucose

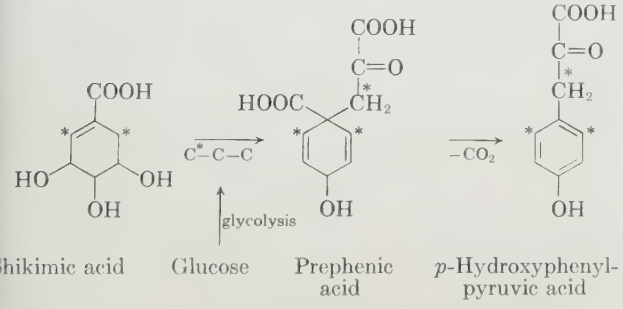


Fig. 11. Aromatization of shikimic acid

which permitted the selective isolation, and determination of the specific activities of carbon atoms 1, 2, 5, 6, 7, and 8 of the vanillin. (see Fig. 8)

A comparison of the relative distribution of activities in the vanillin from the two experiments reveals that appreciable activity is incorporated into carbons 2, 6, 7, and 8 of the vanillin, whereas less significant amounts were incorporated into carbons 1, 3, 4, and 5 (*22*). The results shown in Table VI have been independently confirmed (*23*).

With regard to the mechanism of formation of the six-membered rings, the condensation of two isotopically equilibrated 3-carbon units would afford 6-membered rings containing the two labeled carbons either *ortho* or *para* to each another, depending on whether a "head-to-head" or "head-to-tail" condensation had occurred. (see Fig. 9). But, the experimental data reveal significant activity only in positions 2 and 6 of the ring of the vanillin. A mechanism of ring synthesis from three 2-carbon units, regardless of the sequence or arrangement of the fragments, would result in the labeling of three carbon atoms of the ring with appreciable activity. But the experimental results indicated that only two carbons of the ring were so labeled. Similarly, a mechanism involving the direct cyclization of glucose (or of some derived hexose) to form a 6-membered ring directly must also be eliminated because in such a case, only one carbon of the ring would contain appreciable activity, but two carbons were found significantly radioactive.

Table VII

Carbon Dioxide
↓
Carbohydrate
↓
Shikimic Acid
↓
p-Hydroxyphenylpyruvic Acid
↓
Primary Lignin Building Stones
↓
Secondary Lignin Building Stones
↓
Lignin

The only rational interpretation of the data on the comparative distribution of activities involves the conversion of glucose into the aromatic rings of lignin by the condensation of a triose derived from glucose via glycolysis, with a tetrose derived from glucose via the pentose phosphate pathway. Such a condensation affords an explanation for the activities observed in positions 2 and 6 of the rings of shikimic acid, one of the lignin precursors, and of the vanillin obtained from the degradation of lignin (see Fig. 10).

For the formation of *p*-hydroxyphenylpyruvic acid, which has also been proposed as a lignin precursor, shikimic acid must condense with still another 3-carbon fragment from glucose, followed by the decarboxylation of carbon-7, as for example, from prephenic acid. Figure 11 shows that such a sequence of events would explain the observed activity in position 7 of the isolated vanillin. The activity of carbon-8 of vanillin can be explained on the basis of the conversion of a one-carbon fragment from glucose into the labile methyl group of methionine, which is then utilized for a methylation reaction.

The process of lignification may now be expressed as

follows (*24*) (see Table VII): the ultimate organic source of lignin is the carbohydrate photosynthetically formed by the plant from atmospheric carbon dioxide. This carbohydrate has been identified as D-glucose. The monosaccharide is then cyclized to shikimic acid. This cyclohexene derivative is then aromatized, probably via the prephenic acid pathway to *p*-hydroxyphenylpyruvic acid. This phenylpropane derivative then serves as a common precursor for the primary lignin building stones by a series of successive oxidation and methylation reactions. For example, in softwoods, two building stones, *p*-coumaryl alcohol and coniferyl alcohol, might form lignin by repeated condensations. However, for the formation of hardwood lignins, a syringyl-type building stone, such as sinapyl alcohol, is also required before the final polymerization into the higher methoxyl-containing lignins characteristic of hardwood species.

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Investigations on Lignins and Lignification

XXIII. Hydrogenation and Hydrogenolysis of Native and Milled-Wood Lignins*

CARMINE J. COSCIA, WALTER J. SCHUBERT, and F. F. NORD

Hydrogenation and hydrogenolysis have been employed as a means of comparison of the native and milled-wood lignins of oak and birch. The isolated lignins, characterized by elementary analysis, methoxyl content, ultraviolet and infrared spectra, were subjected to copper "chromite"-catalyzed hydrogenation. Similarities between the lignins were observed in both hydrogen consumption and in the nature of the products. The principal compounds isolated were high-boiling phenols (50–150°C/. 1 mm. Hg) and a glassy methoxyl-containing phenolic residue. The phenols were subjected to spectral and chromatographic analysis. A comparison of the ultraviolet spectra of the phenols obtained from the milled-wood lignins with the spectra of the untreated lignins showed that, although there was no shift of $\lambda_{max.}$, a shift to shorter wavelengths had taken place for $\lambda_{min.}$ In addition, appreciable decreases in both $E_{max.}$ and $E_{min.}$ were observable. The infrared spectra of the phenols differ from the spectra of the untreated lignins principally in the absence of carbonyl absorption at 5.8–5.9 μ and in a relative increase in free hydroxyl absorption at 2.9–3.0 μ and 9.5 μ and in phenolic hydroxyl absorption at 8.2 μ. The hardwood lignins yielded similar hydrogenation products, and evidence indicates a significant resemblance between the degradation products of native and milled-wood lignins.

OF THE degradative methods applied to lignin for the purpose of elucidating its structure, hydrogenation has been most successful, and has provided strong evidence for the hypothesis that lignin consists of phenylpropane "building stones." Harris (*2*), Hibbert (*3*), and others (*4*) have been able to isolate phenylpropane, or cyclohexylpropane derivatives, or both, as products of the high-pressure catalytic hydrogenation of lignin.

However, no study of this type has been reported for a lignin preparation isolated by a method mild enough to permit little or no chemical alteration before hydrogenation. Earlier workers subjected to hydrogenation substances such as Meadol (*8*), methanol and hydrochloric acid lignins (*2*), and even wood itself (*9*). Since the yields of identifiable reaction products were generally low, i.e., 20 to 40%, and since complicated mixtures were usually obtained, large amounts of starting materials were hydrogenated in order to isolate and identify the products. However, lignin preparations isolated under mild conditions, such as "native lignin"

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* See reference (*1*) for previous paper.

Table I. A Comparison of Milled-Wood and Native Lignins of Oak and Birch

	Milled-wood lignin, %			Native lignin, %		
	C	H	OCH_3	C	H	OCH_3
Oak	58.6	6.4	19.5	56.7	5.6	15.5
Birch	58.1	6.4	19.6	62.2	5.9	9.6

(*10*) and enzymically liberated lignin (*11*) are usually obtained in relatively low yields, and only after a tedious purification. An exception is milled-wood lignin, which has been isolated in yields of 60% (*12*). Although the preparative procedure is somewhat lengthy, the conditions of its isolation make this lignin a useful starting material for structural investigation. Accordingly, in the present study of the hydrogenation of hardwood lignins, native and milled-wood lignins were chosen, affording an opportunity to compare them before and after hydrogenation.

EXPERIMENTAL

The native lignins were prepared following the method of Kudzin and Nord (*13*); the milled-wood lignins were obtained as reported in the literature (*12*).

The lignin was subjected to hydrogenation as follows: 1 g. lignin in 50 ml. anhydrous dioxane, with 1 g. copper "chromite†" catalyst was subjected to an initial hydrogen pressure of 100 atm., and heated to 220–250°C. for 48 hr. in a bomb. The catalyst was removed from the resulting solution by centrifugation and the dioxane was distilled through a Vigreux column. The brown concentrate was distilled *in vacuo* over the range 50 to 150°C./1 mm Hg. The distillate and residue gave positive tests with ferric chloride, bromine water, and ceric ammonium nitrate reagents. Both also contained methoxyl groups.

Ultraviolet spectra were measured with a Zeiss PMQ II spectrophotometer. Dioxane was used as solvent.

Infrared spectra were obtained on a Perkin-Elmer double beam recording spectrophotometer. The lignins were analyzed as Nujol mulls. The hydrogenation products were smeared between sodium chloride crystals.

For paper chromatographic analyses, methanol solutions of oak and birch milled-wood lignin hydrogenation products were spotted on strips of Whatman no. 1 paper. The paper was developed with a water-saturated benzene-heptane (1:2) solution, dried, and sprayed with either diazotized *p*-nitroaniline, diazotized *p*-sulfanilic acid followed by 10% sodium carbonate solution (aq.) (*14*), or 1% aqueous phosphomolybdic acid followed by ammonia vapors (*15*). The R_f values were measured in the usual way.

RESULTS AND DISCUSSION

The elementary compositions of the native and milled-wood lignins of oak and birch (Table I) indicate that they are quite different. The variation in methoxyl content of the native and milled-wood lignins is enigmatic, but the values for the latter are in agreement with most data reported for deciduous woods (*5*). Worthy of note is the almost identical elementary composition of the milled-wood lignins. This similarity prevailed throughout the study.

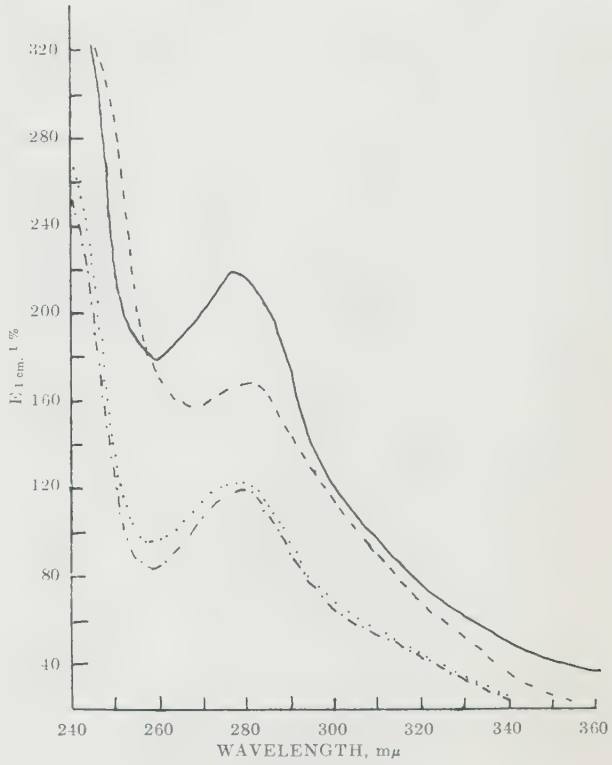

Fig. 1. Ultraviolet spectra of native (NL) and milled-wood lignins (MWL) of oak and birch

—— Oak NL; - - - Birch NL; - · - · - Oak MWL; · · · · Birch MWL.

The ultraviolet spectra in Fig. 1 show maxima at 279 μ for both the milled-wood lignins and the birch native lignin, while the oak exhibits a maximum at 277 μ. Minima are at 259 μ for the milled-wood lignins, at 258 μ for oak native, and 266 μ for birch native lignin. These curves are more characteristic of softwood lignins than of hardwood lignins (*6*).

Table II. A Comparison of the Infrared Spectra of Milled-Wood and Native Lignins of Oak and Birch

Lignin	Infrared Absorption peaks, μ							
Oak, milled-wood	2.95m[a]	5.8w	6.30m	6.66m	7.29s	8.18s	8.92s	9.7m
Oak, native	3.0w	5.8w	6.30w	6.65m	7.26s	8.3w	8.94m	9.8w
Birch, milled-wood	2.95m	5.80w	6.31m	6.67m	7.29s	8.2s	8.93s	9.7m
Birch, native	3.0w	5.89w	6.32m	6.67m	7.28s	8.32s	8.96s	9.79m

[a] m. = medium; s = strong; w = weak.

Similarities between the native and milled-wood lignins are apparent, and again the properties of the milled-wood lignins are almost identical.

Table II gives the most significant absorption peaks of the infrared spectra. All the lignins show characteristic bands in the regions 3.0 and 8.3 μ (hydroxyl absorption), and at 6.3 and 6.6 μ (aromatic peaks). In the 3.0 μ region, the O—H stretching band is broad, indicating hydrogen bonding. The C—O stretching absorption of the phenolic hydroxyl group appears in the 8.2 μ region. The 8.9 μ band is unassigned but may be due to aromatic ether groups (as is the case for the 9.8 μ peak). A weak C=O stretching band occurs in 5.8 μ region in all samples.

†The copper "chromite" catalyst was obtained through the courtesy of The Harshaw Chemical Co., Cleveland 6, Ohio.

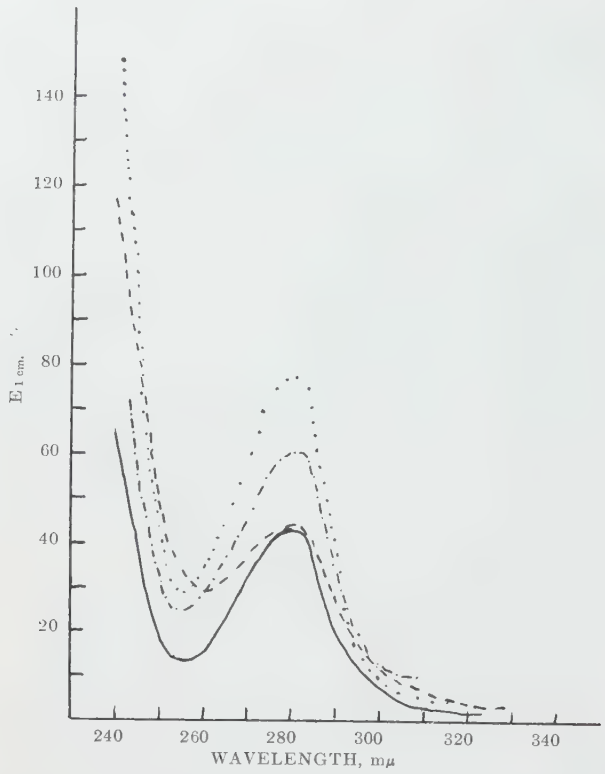

Fig. 2. Ultraviolet spectra of the hydrogenation products of native (NL) and milled-wood lignins (MWL) of oak and birch

—— Oak NL; - - - - Birch NL; - · - · - Oak MWL; · · · · Birch MWL.

Accordingly, the differences among the spectra of the native and milled-wood lignins are in the relative intensities of absorption rather than in the regions themselves. These data are in agreement with those reported for softwoods (*16*).

Upon copper "chromite"-catalyzed hydrogenation and hydrogenolysis of the various lignins, similarities were observed in both hydrogen consumption and in the nature of the products. Between 0.02 and 0.05 mole of hydrogen was absorbed per gram of lignin. Thus, a lignin phenylpropane unit of molecular weight 180 would absorb 3.6 to 9 moles of hydrogen. The lower values appear more reliable, however, since when the larger volumes of hydrogen were consumed, the catalyst underwent a change in color from black to red. This suggested that the (black) cupric oxide was reduced to either the (red) cuprous salt or to copper. If the lower amounts are correct, it would appear that the lignins absorb enough hydrogen to be cleaved to monomeric phenols, in addition to expected reduction of ethylenic double bonds, carbonyl functions and, in some cases, aromatic ring hydrogenation.

The ultraviolet spectra of the hydrogenation products of the lignin preparations, in Fig. 2, support these conclusions. They exhibit maxima at 280 to 281 μ which are similar to those of the untreated lignins; oak native lignin is exceptional. This peak represents the benzenoid or B band shiftde to higher wavelengths by the auxochromic hydroxyl groups, and it is therefore concluded that this function was not removed by hydrogenation. Furthermore, these hydrogenation products exhibit curves which are very similar to those of previously reported (*4*) phenolic hydrogenation products; i.e., they contain a relatively sharp decrease in absorption from 290 to 300 mμ and a deep trough between 250 to 260 μ. The lignin ultraviolet curves (Fig. 1) exhibit a gradual decrease from 290 to 360 μ; this is attributed to chromophores such as conjugated double bonds and carbonyls (*7*). The absence of such chromophoric groups in the hydrogenation products is responsible for the sharp drop between 290 and 300 mμ.

In addition, the loss of conjugation with an aromatic nucleus leads to hypsochromic shifts of the minima and a deepening of the trough (*17*).

A significant change in the absorption spectra is the reduction of the degree of absorbance by 50% or more when compared with the original lignin. This may be due to the hydrogenation of phenolic moieties of the lignin to cyclohexanols, as well as the elimination of aromatic ring-conjugated systems.

The infrared spectral data of the hydrogenation products (Table III) reveal that the broad hydrogen-bonded hydroxyl band at 3.0 μ, the phenolic C—O stretching mode at 8.2 μ, and the aromatic absorption peaks at 6.2 and 6.6 μ are retained and increased. There is a loss of the C=O stretching band at 5.8 μ, as expected. The strong peaks at 3.5, 6.9, and 12.2 μ represent aliphatic C—H stretching and deformation frequencies. In the 9.5 to 9.6 μ region, a broad absorption represents primary hydroxyl C—O deformation. However, methoxyl C—O deformation occurs in the upper region of this band (9.7 μ), and because of the broadness, it is possible that both frequencies occur here. Methoxyl C—O stretching frequencies may also be tentatively assigned to the 7.9 μ band. The fact that the infrared spectrum of dihydroconiferyl alcohol exhibits a similar phenomenon (*18*), and the high methoxyl content of the phenolic mixture support this assumption. Finally, careful fractionation of the dioxane used as solvent in the hydrogenation indicated that it contained only traces of methanol. It is therefore concluded that during hydrogenation, demethoxylation did not occur to any appreciable extent.

Table III. A Comparison of Infrared Spectra of Milled-Wood and Native Lignins Hydrogenation Products

Lignin	*Infrared Absorption peaks, μ*										
Oak, milled-wood	3.0s	3.44s	6.24s	6.61s	6.90s	7.55s	7.90s	8.25s	8.98 s	9.5s	12.2w
Oak, native	3.0s	3.44s	6.24s	6.61s	6.90s	7.5s	7.90s	8.25s	8.94s	9.5s	12.2w
Birch, milled-wood	3.0s	3.5s	6.25s	6.61s	6.89s	7.55s	7.90s	8.25s	8.98s	9.6s	12.2w
Birch, native	2.9s	3.41s	6.20s	6.59s	6.83s	7.50s	7.90s	8.23s	8.92s	9.6s	

The phenolic mixture has been separated into five components by means of descending paper chromatography. The R_f values in Table IV were obtained by developing the chromatograms with a water-saturated benzene-heptane (1:2) solution. Diazotized sulfanilic acid, diazotized *p*-nitroaniline, and, most frequently, 1% aqueous phosphomolybdic acid followed by ammonia vapors, were the chromogenic agents used. Development was carried out at 20 to 25°C., and also at

0 to 5°C., because of the relatively high volatility of certain of the compounds under investigation. By this method, two of the five spots obtained have been identified as dihydroconiferyl alcohol and dihydroeugenol. Owing to their elongated nature, the other two mobile spots gave indefinite R_f values. In addition, one of these spots was multicolored, indicating the presence of more than one compound. Hence,

Table IV. R_f Values of Milled-Wood Lignin Hydrogenation Products and Model Compounds

Material	*Spot*	*Temperature, °C.* 0–5	20–25
Hydrogenation products of birch milled-wood lignin	I	0	0
	II	0.03	0.08
	III	0.5	0.7
	IV	0.7	0.8
	V	0.86	0.89
Hydrogenation products of oak milled-wood lignin	I	0	0
	II	0.03	0.08
	III	0.5	0.7
	IV	0.6	0.8
	V	0.86	0.89
Dihydroconiferyl alcohol		0.03	0.08
Dihydroeugenol		0.86	0.89

a more sensitive means of separation is necessary for the resolution of this mixture of phenols.

Isolation and identification of the constituents of this mixture should reveal additional information on the chemical characteristics of the original lignins themselves. Furthermore, since the lignins studied were isolated under mild conditions, evidence of these structures should be most valuable in the elucidation of the nature of lignin *in situ*.

SUMMARY

1. Native and milled-wood lignins of oak and birch woods were prepared; they exhibited variations in their elementary compositions and methoxyl contents but compared favorably with each other in infrared and ultraviolet spectral analyses.

2. These lignin preparations were subjected to catalytic hydrogenation and hydrogenolysis, yielding a high boiling mixture of phenols and possibly some cyclohexyl compounds. All samples absorbed essentially the same amount of hydrogen. Demethoxylation did not occur.

3. The phenolic mixture was subjected to infrared, ultraviolet, and chromatographic analyses, which indicated that the material contained guaiacyl compounds with propyl side-chains.

4. Similarities in hydrogenation products indicated a resemblance of milled-wood lignin to native lignin.

5. The two different wood species yielded similar hydrogenation products; both the milled-wood lignins and their hydrogenation products were almost identical.

6. More sensitive means of isolation and identification of the constituents of the phenolic mixture should provide information on the structure of the lignins *in situ*.

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Environmental and Genetic Variability in the Length of Fibers of Eastern Cottonwood

STEPHEN G. BOYCE and MARGARET KAEISER

The mean length of fibers among 83 trees at 4.5 ft. from the ground ranged from 0.85 to 1.28 mm. The number of annual rings and the diameter accounted for at least 50% of the variation. The genetic variance was estimated to be less than 2.0 mm. for trees 18 in. in diameter at 20 yr. of age. The results of this study can be used to identify trees with fibers inherently longer than the average for natural trees.

The first step toward improving the quality of trees through selection is to determine the range of variability of quality characteristics and then to find out how much of this variability is inherited and how

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much is caused by environment. We did this for the length of fibers in eastern cottonwood (*Populus deltoides* Bartr.), because fiber length is related to certain wood properties and is important in the manufacture of certain papers (*15*).

Our results agree with the findings of previous studies which indicated that fibers of cottonwoods and other poplars differed inherently and that fibers near the bark were longer than those near the pith (*3–8, 10, 14*). We determined the amount of variation in the length of fibers that was related to the age and to the diameter of the tree. After deducting for errors in sampling, we subtracted this amount of variation from the total. The remainder, about 30%, is an estimate of the amount of inherent variation in the length of fibers.

These results are useful for selecting inherently superior trees. The equations developed can be used to help identify cottonwood trees that have fibers inherently longer than the average for natural trees. And, the range of variation indicates the maximum increase in the length of fibers that can be expected after many generations of selections.

METHOD

Wood samples were removed from 83 dominant trees located in southern Illinois, southern Indiana, western Kentucky, and eastern Missouri. Four increment cores were taken at 4.5 ft. from the ground and at 90° intervals around the stem of each tree. Each increment core was 5.2 mm. in diameter and extended from the cambium to the pith (*2*). From these four cores, we determined the number of annual rings, the average width of each fifth ring. and the average diameter for each fifth year of growth. Then, the segments of each fifth ring from the pith were cut from the cores and macerated (*5*). A sample of fibers was removed from each maceration and spread thinly over a 2 by 3-in. glass slide. The slide was clamped to the mechanical stage of a microprojector and, by a systematic pattern of traverses, 100 whole fibers were selected for measuring. The image of each fiber was magnified 49.05 times and projected onto a sheet of white paper. Lengths of the fibers were determined by measuring the lengths of the images in millimeters. We used the percentage of cross-sectional area sampled by each fifth ring as a basis for computing the average fiber length of each cross-section.

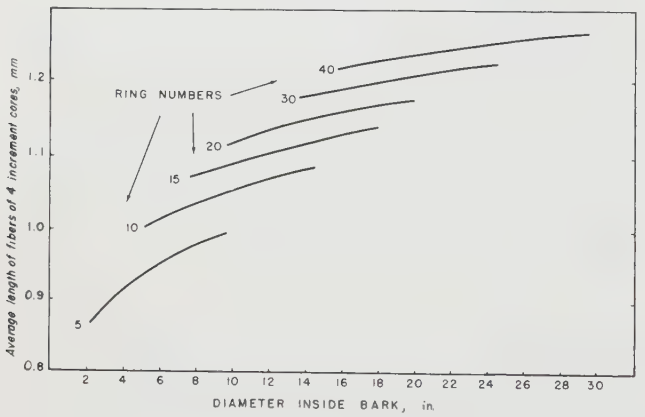

Fig. 1. The average length of the fibers of each ring increased with the number of the ring from the pith and with the diameter of the tree

Multiple correlation coefficient = 0.67
Standard error, mm. = 0.07
Average length of fibers, mm. = 0.42551 + log of ring 0.2119 + (log d.i.b. inch × 12.7) 0.1960

We selected trees from several different sites. About half of the trees were growing in bottomland soils along the Missouri, Mississippi, and Ohio Rivers; 24 trees were growing in upland swales and covers, or on slopes, and ridges; and 11 trees were growing on strip-mined land.

In large stands more than one tree was sampled, but sampled trees were at least 1/4 mile apart. Each sampled tree had less than 4° lean, an intact and well-developed crown, and no fire scars or other apparent injuries. For each tree we recorded the total height, the diameter, the location, the texture of the soil, associated vegetation, and other features such as evidence of flooding height. Site index values, based on height at age 25, were calculated for each tree (*11*).

RESULTS

Variation Among Rings

The average fiber length of the individual growth rings measured in a single tree ranged from 0.70 to 1.38 mm. The longest and shortest fibers were 2.19 and 0.25 mm. The length of the fibers increased with the number of the ring from the pith and with the diameter of the tree (Fig. 1). The logarithm of the number of the ring and the logarithm of the diameter inside the bark (d.i.b.) could be used to predict the average length of fibers for each ring with a standard error of 0.07 mm. and a coefficient of variation of 7.0%. Age of the ring accounted for about 64% of the variation among rings of the same tree while differences in tree diameter for rings of the same age accounted for about 3% of the variation. After the variations related to age and diameter were removed from the data, there was no correlation between length of fibers and mean annual growth or width of the ring. However, if diameters were omitted from the equations of least squares, then width of the ring became significant. Both of these variables indicated the influence of the rate of growth; but diameter had the highest correlation.

Trees with fibers longer than the average when young had longer-than-average fibers at older ages. This was shown by the relatively high correlation coefficients for mean fiber length among rings of the same tree (Table I). The closer the rings, the higher the correlation coefficients, but the coefficients were still statistically significant between the 5th and 25th rings. The 20th ring from the pith had the highest correlations with all other rings and was the best ring for comparing fiber length between trees.

Table I. Correlation Coefficients (*r*) for the Length of Fibers of Early Rings and Succeeding Rings in Young Trees

Early ring	*Succeeding rings* 10	15	20	25
5	0.52[a]	0.53[a]	0.49[a]	0.49[b]
10		0.72[a]	0.61[a]	0.37[b]
15			0.64[a]	0.50[a]
20				0.59[a]

[a] Significant at the 1% level of probability.
[b] Significant at the 5% level of probability.

Environmental Variation Among Trees

The average fiber length of the 83 trees at 4.5 ft. from the ground ranged from 0.85 to 1.28 mm. The average fiber length of the four increment cores was related to the number of rings and to the diameter of each tree (Fig. 2). The logarithm of the number of rings and the diameter inside the bark could be used to predict the average fiber length of the four cores with a standard error of 0.06 mm. and a coefficient of variation of 5.5%. The number of rings accounted for about 46% of the variation while differences in diameter for the same number of rings accounted for about 4% of the variation.

No other indices of environmental conditions were found to be correlated with the length of fibers. There were no differences in the average length of fibers among trees growing on bottomland, upland, and strip-mined sites. After the variations related to the number of rings and to diameter were removed from the data, differences in mean annual increment, site index value, height of flooding, texture of the soil, elevation, and associated vegetation were not correlated with average length of fibers.

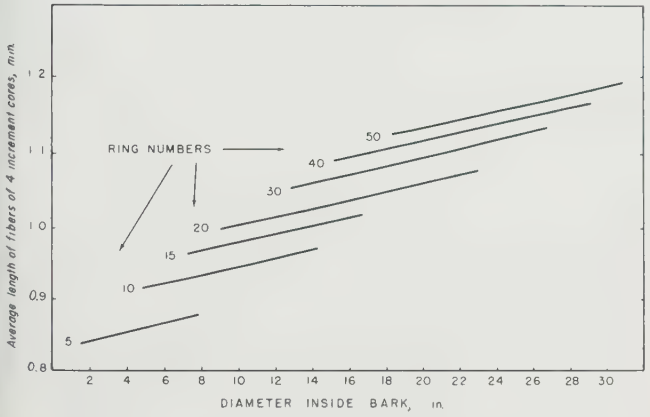

Fig. 2. The average length of fibers of the four increment cores increased with the number of rings and with the diameter of each tree

Multiple correlation coefficient = 0.71
Standard error, mm. = 0.06
Average length of fibers, mm. = 0.70435 + log of rings 0.18346 + d.i.b. (inch) 0.00634

Age and diameter are good indices of the total environmental variation which was estimated to be about 50%. Age is indicative of physical and chemical changes that occur in the cambial region of the tree. These changes, such as differences in the concentration of chemical compounds, changes in the length of the cambial initials, and changes in pressures, influence the length of fibers (*13*). These changes are apparently constant with age since we found the rate of change in the length of fibers with age to be the same for all trees. For each of the 83 trees we calculated the coefficients for the regression of length of fibers on age. We then tested the relation of these coefficients to the indices of external environmental conditions. Neither the coefficient for the slope of the curve nor the coefficient for the intersection of the x-axis was related to site index values, height of flooding, texture of the soil, elevation, or growing site; i.e., bottomland, upland, or strip-mined areas.

In contrast to age, differences in diameter indicate environmental relationships that are related to stand density and site. Environmental conditions that increase the width of the growth rings also increase the average length of the fibers. Within a growth ring the length of the fibers increases from the inner to the outer part of the ring (*1, 12*). Thus, the wider the rings the greater the volume of wood with long fibers and the higher the average length of fibers for the tree.

The average length of fibers in the cross-section of each tree was higher than, but was directly related to, the average length of fibers of the four cores. Averages for the four cores were used in the analyses because they were easier to calculate. However, the average length of fibers of the cross-sections could be estimated, with a standard error of 0.02 mm., by multiplying the average length of fibers of the four cores by 0.998 and adding 0.027.

Inherent Variation

The length of fibers was assumed to be determined by the hereditary genotype and by the environment of each tree. Because the trees had different genotypes and developed in different environments, we could not completely separate environmental and inherent variability. However, we could obtain relative estimates. Since all the trees came from seed, and were part of a freely interbreeding population with no known barriers to crossing, every genotype probably had equal opportunity to occur in every environment. Among a large sample of trees, 83 for this study, any relations between the rate of growth and the length of fibers are expressions of environmental effects unless genes for a certain length of fibers are linked with genes for survival on certain sites. Therefore, age and diameter were thought to account for most of the environmental variation.

Table II. Average Fiber Lengths (Measured and Expected) of Trees with Longest and Shortest Fibers

Tree	*Annual rings at 4.5 ft., no.*	*Average diameter inside bark, in.*	*Measured[a] length of fibers, mm.*	*Expected[b] length of fibers, mm.*	*Deviations from the expected, mm.*
		Trees With Longest Fibers			
42	14	13.1	1.13	0.99	+0.14
47	22	21.1	1.21	1.09	+0.12
39	33	22.0	1.22	1.12	+0.10
76	25	16.3	1.15	1.06	+0.09
16	12	7.9	1.04	0.95	+0.09
		Trees With Shortest Fibers			
36	24	21.2	0.97	1.09	−0.12
29	22	15.5	0.95	1.06	−0.11
4	20	12.8	0.92	1.02	−0.10
30	27	18.3	0.99	1.09	−0.10
67	35	23.3	1.04	1.13	−0.09

[a] Average of four radial cores.
[b] From the equation mean fiber length = 0.70435 + log. of age 0.18346 + d.i.b. (in.) 0.00634.

In contrast to age, differences in diameter indicate environmental relationships that are related to stand density and site. Environmental conditions that increase the width of the growth rings also increase the average length of the fibers. Within a growth ring the length of the fibers increases from the inner to the outer part of the ring (*1, 12*). Thus, the wider the rings the greater the volume of wood with long fibers and the higher the average length of fibers for the tree.

The lines in Fig. 2 indicate the average length of fibers for trees with the most frequent genotypes. Deviations from the lines are caused by errors of sampling, by inherent differences among trees, and possibly, by unidentified environmental conditions. If we assume an error of 20% in determining the environmental variation and accept the estimated environ-

mental variation of 50%, then the relative inherent variation is at least 30%. We believe our estimate of error, 20%, is rather large and that the inherent variation is probably higher than 30%. Also, if environmental differences are reduced by growing clones of these trees in the same environment, then the inherent variation is expected to be higher (*9*). Although there is some error in our estimate of inherent variation, it is valuable until a better estimate can be made by growing the trees in a uniform environment.

HOW TO IDENTIFY INHERENTLY SUPERIOR TREES

The regression equations and charts can be used for identifying trees with fibers inherently longer or shorter than the average for the population. For screening large numbers of trees of different diameters and ages, the average length of fibers of several rings should be used.

Using tree number 42 (Table II) as an example, we can show how an inherently superior tree can be recognized. At 4.5 ft. from the ground take four increment cores, each spaced at 90° intervals around the stem. These cores should be at least 5 mm. in diameter and extend from the cambium to the pith (*2*). Tree no. 42 has 14 annual rings and is 13.1 in. in diameter inside the bark. The first four rings of the increment core are discarded since they contain very short fibers. The fibers from the cores have an average length of 1.13 mm. From the lines in Fig. 2 or for greater accuracy, from the regression equation, we find that the average length of fibers for a tree of this size and age is 0.99 mm. Thus, fibers of tree no. 42 average 0.14 mm. longer than those of the average tree. This difference is equivalent to slightly more than 2 standard deviations from the average for the population. If we have not made a large error in sampling, we can feel confident that tree no. 42 has an inherent ability to form fibers longer than those of the average tree.

If several trees are selected from a natural population by this method, most of them can be expected to be inherently superior for length of fibers. A few mistakes may be made in selecting trees because of errors in sampling and in determining the average length of fibers, but later clonal tests will identify these trees so they can be eliminated from the selections.

Our results also show that trees with inherently long fibers can be selected from test plantings when the trees have only five annual rings at 4.5 ft. This is true because the average length of fibers of the 5th ring is correlated with the average length of fibers of later rings (Table I).

POSSIBLE IMPROVEMENT THROUGH SELECTION

Selection of trees with the longest fibers for 10 or more generations should result in clones with fibers longer than the average for natural cottonwood stands. The first selections from natural stands should have fibers about 10% longer than those for the average tree (Table II). Repeated selections from the offspring of trees with the longest fibers could eventually result in an even greater increase in the average length of fibers. However, the rate of gain for a selected characteristic usually decreases with each selected generation (*9*). From our data we cannot predict the rate of gain from subsequent selections, but we can indicate the maximum average length of fibers that can be expected from a selection program. The average lengths of fibers of 20-year-old natural trees, 18 in. in diameter range from 0.92 to 1.14 mm. But, the longest individual fibers in these trees are about 2.19 mm. and represent about the maximum length of fibers in eastern cottonwood. Thus, the maximum length of fibers that can be attained through selection for trees of this age and size is between 1.14 and 2.19 mm. Since the genetic variance is about 30% and since not all of this variance would contribute toward a selective increase, the maximum average length of fibers that can be expected through selection is probably less than 2.0 mm. for trees 18 in. in diameter at 20 yr. of age.

SUMMARY

For natural cottonwood trees growing in Missouri, Illinois, Kentucky, and Indiana we estimated the amount of environmental and inherent variation in the length of fibers. Mean length of fibers among 83 trees at 4.5 ft. from the ground ranged from 0.85 to 1.28 mm. The number of annual rings and the diameter accounted for at least 50% of the variation. The genetic variance was estimated to be about 30%. The maximum average length of fibers that can be expected after several generations of selection was estimated to be less than 2.0 mm. for trees 18 in. in diameter at 20 yr. of age. The results of this study can be used to identify trees with fibers inherently longer than the average for natural trees.

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Surface Wettability of Coated Paper

A Photomicrographic Technique for Measuring the Contact Angle of Water on Printing Papers

CORNELIUS B. WESTERHOFF, RICHARD L. SAVAGE, and JAMES A. REYNOLDS

The photomicrographic technique is based on the use of a Polaroid-Land microscope attachment for obtaining a permanent record of the contact angle of a drop of water immediately after the drop has been formed on the surface of the coated paper. Interpretation of the results is based on the premise that a high contact angle is indicative of low surface activity and, therefore, of good press operability. This method permits the measurement of the initial contact angle from a photograph with considerable accuracy. Since the contact angle decreases continuously with time, it is important to obtain the initial reading.

Among the requirements of coated offset printing papers is a low surface wettability. If wettability can be reduced to a point where even a transitory degree of water repellency is attained, press operability is enhanced. Perhaps this can be more readily illustrated by describing the operation of the offset printing process. Figure 1 is a diagram of a typical offset press unit. The essential features are the plate cylinder on which the planographic printing plate is mounted, the rubber-covered blanket cylinder, the backing or impression cylinder, inking rolls, and a dampening system. The operation consists of dampening the plate with fountain solution, which is an aqueous solution of ammonium dichromate, gum arabic, and phosphoric acid. The fountain solution is adsorbed on the hydrophilic nonworking area of the printing plate. The printing areas, being hydrophobic, repel the dampening solution. The plate is then contacted by the inking rolls; the moist nonprinting areas rejecting the ink while the working areas accept it. The image is then printed on the rubber blanket—both ink and fountain solution being transferred. The actual printing of the sheet is then done from the blanket; again both ink and the film of fountain solution being transferred. Each press unit prints a single color. If color work is being done, a press consisting of four or more of these units is normally used.

Although the use of dampening solution is essential to maintain the oleophobic properties of the nonprinting areas of the plate, this moisture can be responsible for a variety of printing difficulties. For example, if the coating adhesive is water sensitive, it may be softened by contact with the fountain solution on the blanket losing its binding strength. This results in rupture of the coating film in the printing areas and is referred to as picking. It can also result in picking off the coating pigments in the nonprinting areas by the tacky rubber blanket. This gradual accumulation of pigment on the blanket is called piling.

Piling and picking difficulties have frequently been overcome by the use of less water-sensitive adhesives in the coating. The criterion for rating such coatings has been the familiar wet-rub test.

Although a coating may be highly resistant to wet abrasion, this does not guarantee satisfactory press performance. Insolubilizing the coating adhesive does not prevent the penetration of dampening solution through the interstices of the porous coating film. During prolonged press runs, sufficient water soluble surface active materials may be leached from the coating to cause ink and plate problems.

For example, if the surface active material from the coating works back into the dampening system, the plate will become desensitized and nonprinting areas will become ink-receptive. This is referred to as scumming or plate-blinding. It is also possible that sufficient surface-active fountain solution will work back into the ink system to cause an inversion of the normal water in ink emulsion. This ink-in-water emulsion will wet the nonprinting area of the plate causing overall printing or tinting. Therefore, whether a coating is sized with protein, casein, starch or latex, one of the important factors which will determine how suitable it will be for multicolor offset printing is the quantity of surface-active material capable of being leached from the sheet surface during the printing operation. The tendency for this to occur is logically related to the surface wettability of the coated sheet. Coatings which tend to be nonwetting are an unlikely source of surface active contamination. On the other hand, coatings in which the surface active material is readily available will have a high surface wettability and may cause offset press difficulties.

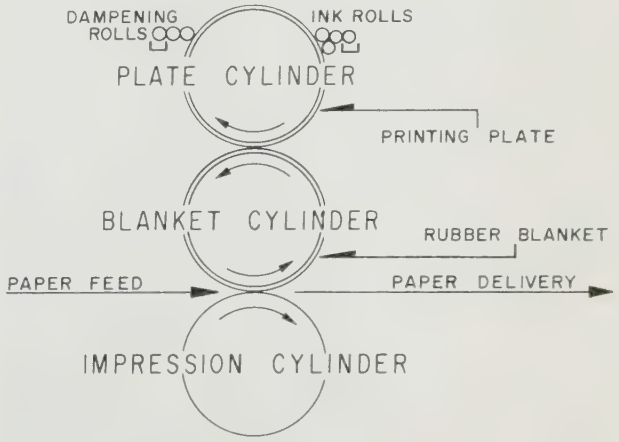

Fig. 1. Offset printing press

This fact has been recognized in the industry and several tests have been developed as a means of rating the surface-active properties of paper coatings. Among

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the methods used is the Bitter's test (*1*) and the Lithographic Technical Foundation's modification of the Bitter's method. Both involve measuring the reduction in surface tension of a dilute phosphoric acid solution caused by immersion of the coated sheet in the

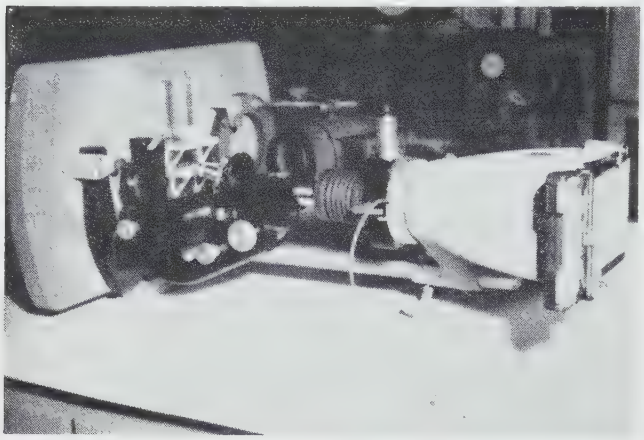

Fig. 2. Contact angle apparatus

acid. In addition, TAPPI Standard T 458 m-59 (*2*) outlines a procedure for determining the wettability of uncoated printing papers by measuring the angle of contact with a static drop of water.

PROCEDURE

We have devised a photomicrographic technique based on the TAPPI Standard. It differs, primarily in that the angle of contact is recorded photographically within the first 0.5 sec. after the drop has been formed on the paper. The apparatus used is shown in Fig. 2. It consists of an American Optical No. 682B photomicrographic camera with a No. 500 Polaroid Land film holder attachment and a special stage constructed of clear polymethacrylate plastic. The stage, illustrated in Fig. 3, supports a 10 microliter (μl.) syringe and the sample of coated paper under test

The method consists of the application of a 1 μl. drop of 0.1% phosphoric acid, used to simulate fountain solution, to the surface of the paper and immediately recording the contact angle so formed by photographing the drop through the microscope at $\times$ 20 magnification. The contact angle can be directly determined from the photograph with considerable accuracy by drawing a tangent to the drop at the point of contact and measuring the internal angle so formed. Figure 4 shows the contact angles of coatings prepared from two commercial latices.

Fig. 3. Sample stage

From a series of photographs such as these, it is possible to plot the rate of surface wetting of a coating. However, because the original purpose in developing this method was to obtain a rapid means of comparing

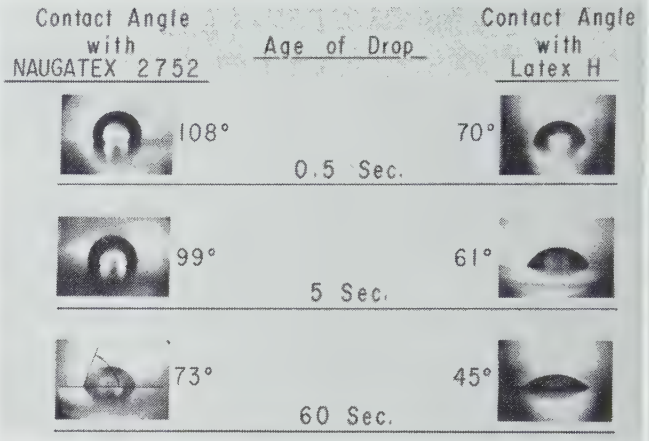

Fig. 4. Effect of latex on surface wettability of coated paper

experimental coatings, it was decided to use a single photograph to characterize each coating. For reasons of reproducibility, a definite time after contact of the drop with the coated surface and before the shutter was tripped had to be established. Since this test is intended to rate coated papers for high-speed offset printing where very short contact times are involved, it was assumed that for greatest significance the photograph must be made as soon as possible after contact. In practice it took approximately 0.5 sec., from the time the drop was observed to make contact, to remove the hypodermic syringe and to trip the shutter. This was adopted as a standard.

Although some slight variation from the 0.5-sec. interval probably exists in practice, this appears to be a relatively minor source of error. The series of photos in Fig. 5 illustrate this point by showing fairly good

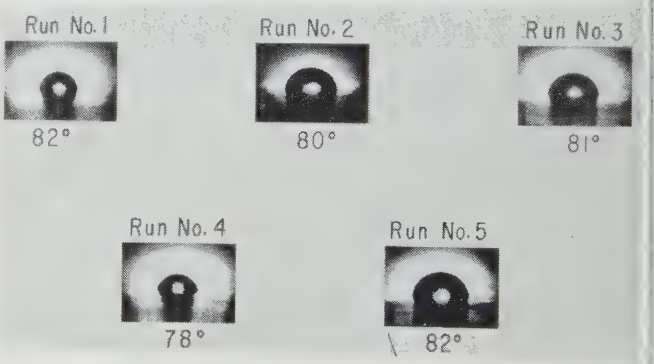

Fig. 5. Reproducibility of contact angle

reproducibility between several determinations made on the same coating. They also indicated that varying the size of the drop from 0.5 to 1.5 μl. causes no significant change in results obtained.

DISCUSSION

Our primary interest in this means of measuring surface wettability has been its use as a tool in developing

a new latex adhesive for paper coating. Substantial differences in the surface wettability of the final coating have been found to result from relatively small differences in polymerization recipe. The contact-angle method has permitted assigning a numerical value to

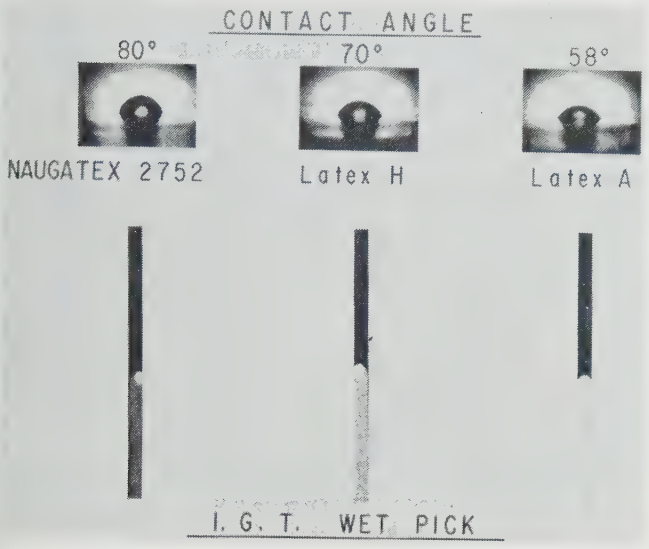

Fig. 6. Comparison of surface wettability and wet pick resistance

each polymerization variable, thus rating its effect on offset printing characteristics. This test also proved to be faster and more reproducible than others which were

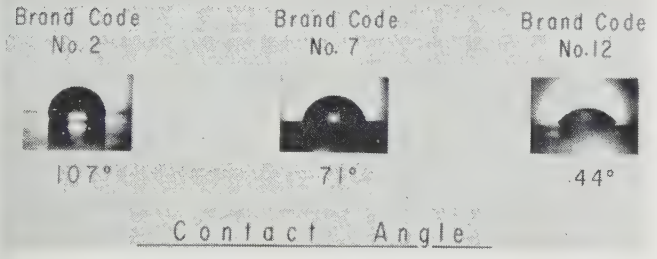

Fig. 7. Surface wettability comparison; commercial offset papers

investigated, and has now been adopted as a standard procedure in our paper laboratory.

Wet Pick

To illustrate another application of this new test method, a number of samples of coated papers employing various commercial latices were checked for contact angle. Three of these are shown in Fig. 6. For comparison, a wet pick test on each sample is also illustrated. This is run by applying a drop of water to the sheet just prior to a normal IGT printing pick test. It is readily apparent that the more wettable the surface, as indicated by contact angle, the poorer the resistance to wet pick. Whereas the latter test can only be rated qualitatively, the contact angle can be measured accurately and a quantitative value assigned to each coating.

It is interesting to note, in Fig. 7, the comparison of contact angles formed on sheets of three commercially coated offset papers. In this case, since different coating formulations were undoubtedly employed, no conclusions on wet pick can be legitimately made. But, the angle would still be indicative of possible ink and plate problems.

Surface Tension Reduction

As was mentioned earlier, the Lithographic Technical Foundation (LTF) has done considerable work on measuring the surface activity of coated paper. Since it is stated (*3*) that some correlation between their tests and actual press performance has been found, it seemed logical to compare contact angle of several coatings with surface tension data.

To avoid effects of extractables in the base paper on surface tension in this work, the LTF method was modified so that, instead of immersing the sheet, 10 ml. of dilute phosphoric acid was allowed to flow over a definite area of the coated surface at a constant rate. The surface tension of this solution was then measured and the reduction caused by the extracted surface-active agents was recorded. Relatively large variations in surface tension measurements on some samples were obtained and it seemed desirable to take the average of the results of 10 separate measurements to obtain a result of greater significance. Table I correlates some

Table I. Comparison of Surface Wettability for Four Coating Latices

Latex	*Contact angle, deg.*	*Surface tension reduction, dynes/cm.*
Naugatex 2752	90	0.5
Latex B	87	0.8
Latex A	82	1.8
Latex C	79	2.4

of these data with contact angle for a series of four commercial styrene–butadiene latices in the same coating formula. A direct relationship appears to exist: the more wettable the surface, as measured by contact angle, the greater the depression of surface tension of the simulated fountain solution. The simplicity, speed, and convenience of the contact angle method, however, far outweighs the intricate technique required for accurate surface tension measurement.

CONCLUSION

We have attempted to show how contact angle measurements could be used to advantage in the development of improved offset papers and in routine quality control testing. As a research tool, we have found the method to be particularly valuable in formulating a new coating latex with exceptionally high resistance to surface wetting.

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High Efficiency Melamine Wet-Strength Resins

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Melamine resin colloids that are highly effective in imparting wet strength to paper under low or high sulfate conditions can be prepared by using extra formaldehyde with the basic trimethylol product, if the amount of acid used is adjusted so as to maintain the optimum pH in the aged colloid. Evidence indicates that the improved high efficiency colloidal particles have an appreciably higher bound-formaldehyde content than their unimproved (regular) counterpart, and that loss of this formaldehyde during curing accounts for the improved efficiency

For years melamine-formaldehyde resin has been commercially used as an effective wet strength agent in paper products that have varied from unsized toweling to supersized map paper. For use, the resin was prepared as a cationic acid colloid that is picked up almost instantaneously and almost quantitatively by the water-dispersed, negatively charged pulp fibers. The basic process has been studied in some detail and is well covered in available literature (*1–9*).

This melamine resin colloid is effective in all types of cellulosic pulps, and imparts bonds that are resistant to hydrolysis. It is effective either with or without alum but if high quantities of alum are used in a tight mill system the sulfate concentration will build up to a point where the colloid efficiency is adversely affected. Other polyvalent anions behave similarly (*3*) but are usually not encountered under papermaking conditions. A continuous effort has been made to overcome the sulfate sensitivity and to otherwise improve the efficiency of the colloid; but until recently, with no real success.

The breakthrough occurred when it was observed that a large excess of formaldehyde, under certain conditions, caused unexpected changes in the behavior of the colloid. The most notable of these changes, economically, were: (1) overall improvement in wet strength efficiency, and (2) insensitivity to sulfates. Considerable effort was made to determine what physical or chemical changes in the colloid had taken place to give these improvements. Some answers are still not clear.

During the early work on melamine resins for wet strength, a resin composition of 1 mole of melamine (M) to 3 moles of formaldehyde was found to be the most effective under the conditions then used. It was also found that the composition of the colloid formed from this 1:3 MF (melamine-formaldehyde) resin became 1:2 during aging, with 1 mole of free formaldehyde formed. The first inkling of a colloid of improved efficiency was given when an aged MF colloid (1:2 with 1 mole of free formaldehyde) was treated with a large excess (5 to 10 mole) of additional formaldehyde, and aged again for several hours. Not only was the wet strength imparted by the colloid appreciably higher, but also excellent wet strength was obtained under high sulfate conditions.

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When the experiment was repeated, this time adding the same amount of formaldehyde *before* the colloid formed, no improvement in efficiency or sulfate stability was obtained. It was therefore tentatively concluded that a double-aging period was necessary, one to develop the regular colloid* and the second to transform this regular colloid to the high efficiency (HE) colloid† after the addition of extra formaldehyde.

The pH of these colloids gave the next clue. Even though the HCl contents of the regular and HE colloids were exactly the same (M:HCl mole ratio about 1:0.8), the HE had an appreciably lower pH after aging (about 1.2 instead of 1.7) (Fig. 1). The additional 5 moles of formaldehyde did not immediately lower the pH; but with time it apparently reacted, split off free HCl from the polymer and caused the drop. The next step was to use less HCl (M:HCl mole ratio 1:0.6) with the HE formulation so that the pH after aging was

* The regular colloid referred to throughout this article is prepared from trimethylol melamine (sold commercially as Parez[R] Resin 607) according to the published procedure (*10*). This product is identified as MF_3.

† Unless otherwise noted, all HE colloids referred to have an MF mole ratio of 1:8 and are made by adding 5 mole of formaldehyde to the trimethylol melamine product. This is identified as MF_8.

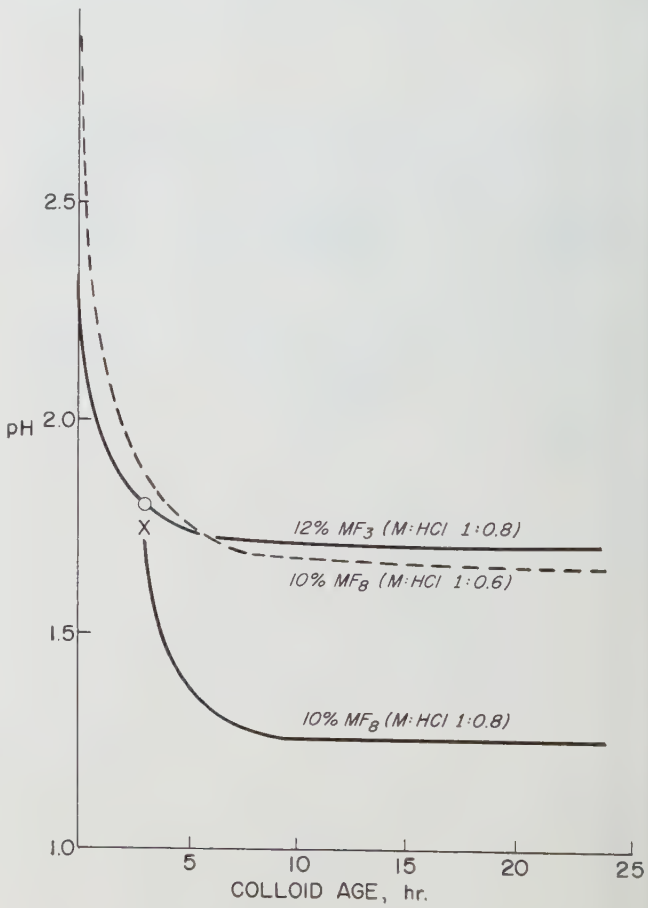

Fig. 1. pH of melamine resin colloids

MF_3 = regular colloid; MF_8 = HE colloid.

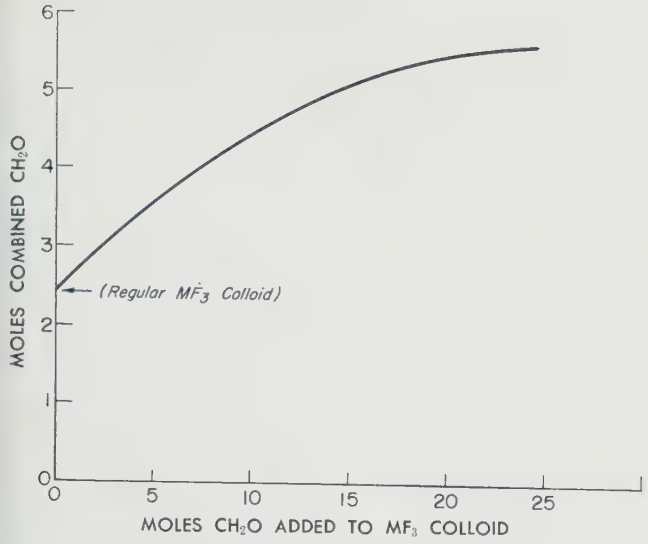

Fig. 2. Bound vs. added CH_2O

about 1.7. This resin solution aged to a typical HE colloid in a single 3-hr. aging period. The new process was ready to be field-tested.

CHARACTERIZATION OF THE HIGH EFFICIENCY COLLOID

The additional formaldehyde was obviously changing the character of the colloid, probably by increasing the amount of bound formaldehyde. Several approaches were taken to determine the bound formaldehyde and all of them agreed fairly well. Two of the methods, a micro- and a macromethod, involved the determination of free formaldehyde in the system in which the total was known, and the "bound" formaldehyde taken as the difference. The macromethod involved the well-known (*11*) reaction of sodium sulfite with formaldehyde to liberate NaOH, which can then be determined quantitatively. With large amounts of formaldehyde present it was found that the reaction time between the sulfite and the formaldehyde had to be longer than recommended in the original procedure; but with this modification, excellent results were obtained

The micromethod involved the measurement of the color intensity developed from the reaction of formaldehyde with phenylhydrazine. For this a G.E.* spectrophotometer was used. Because of the extreme dilutions necessary (1:1000 or greater) this method was not quite as satisfactory as the sulfite method.

In a third procedure formaldehyde "tagged" with C^{14} was used in the preparation of the resin colloids. The radioactivity of the bound formaldehyde was then determined directly on the resin-treated paper.

The three methods of determining "bound" formaldehyde in colloids prepared with various amounts of formaldehyde agree very closely. Figure 2 shows a typical curve of added vs. bound formaldehyde.

It had now been established that the HE colloid had more bound formaldehyde than the regular, and that it was more effective in imparting wet strength. If the increase in bound formaldehyde is simply due to mass action driving additional formaldehyde to the colloid, dilution of the system should favor more free and less bound formaldehyde. Simple dilution work tended to confirm this. For instance, in determining formaldehyde by the micromethod (at 1:1000 dilution) the "free" formaldehyde of HE colloid solutions increased steadily with time. In another experiment, samples of regular and HE colloids were dialyzed through a cellophane membrane for several days. The HE colloid lost most of its formaldehyde (both free and bound) and behaved like a regular colloid with respect to wet strength efficiency at low and high sulfates. Table I shows the composition of the dialyzed and undialyzed colloids.

Because the regular and HE colloids behaved so differently in dilute paper stock under high sulfate conditions, it was thought that the behavior differences might be more easily observed in the absence of pulp. After a few preliminary trials it was found that differences between the colloids were more easily noted under very dilute conditions, and a resin concentration of 0.05% was chosen to work with. It was observed that freshly diluted HE colloids were much more resistant to precipitation than regular colloids, but that this resistance became less as the dilute colloid aged. Table II shows that this loss in sulfate stability is tied in with wet strength efficiency.

Table IIA. Sulfate Concentration (p.p.m. $SO_4^=$) Required to Precipitate 0.05% Resin Colloid

	After standing, hr.			
	0	6	16	65
HE colloid	1100	600	400	300
Regular colloid	150	120	110	100

Table IIB. Change of Wet Strength Efficiency After Storage at 0.05% Resin Colloid

HE storage time, hr.	Wet burst strength of paper treated at	
	Low SO_4	High SO_4
0	15	12
24	14	7

EFFICIENCY OF VARIOUS MF COLLOIDS

To determine the improvement in wet strength efficiency due to the extra formaldehyde, colloids prepared with 1 to 10 extra moles (over the 3 moles present in the regular melamine resin) were evaluated in bleached kraft pulp at various levels of resin addition and at high (1625 p.p.m.) and low (25 p.p.m.) sulfates.

* General Electric Co., Schenectady, N. Y.

Table I. Effect of Dialysis on High Efficiency (HE) and Regular Melamine-Formaldehyde (MF) Colloids

Resin description	Solids as MF_3, %	pH	Cl^-, %	N, %	Melamine, %	CH_2O, %	M:F mole ratio	Wet tensile, lb./in. (2% resin added)	
								Low SO_4	High SO_4
HE	5	1.9	0.5	1.84	2.76	5.4	1:8.2	8.5	7.5
HE dialyzed	4.2	5.9	0.03	1.56	2.34	1.6	1:2.9	7.0	1.3
Regular	5	2.3	0.5	1.82	2.73	2.0	1:3.1	7.9	5.0
Regular dialyzed	3.5	5.4	0.03	1.28	1.92	1.0	1:2.1	6.1	1.2

Table III. Mill Made Papers Containing High Efficiency (HE) Colloid

Fiber type	Basis Wt.,[a] lb.	HE Colloid (MF_3) Resin added on fiber, %	HE Colloid (MF_3) Tensile strength, lb./in. Dry	HE Colloid (MF_3) Tensile strength, lb./in. Wet	Regular colloid (MF_3) Resin added on fiber, %	Regular colloid (MF_3) Tensile strength, lb./in. Dry	Regular colloid (MF_3) Tensile strength, lb./in. Wet
Alpha-cellulose sulfite blend	72	2.0	27.0	9.5	2.0	25.9	8.0
Bleached kraft (softwood–hardwood blend)	46	0.43	21.4	5.0	(0.68	20.0	4.4)[c]
Bleached kraft sulfite blend	58	0.75	42.2[b]	14.1[b]	(1.0	37.8[b]	11.4[b])[c]
Bleached sulfite	39	2.0	19.1	7.2	2.0	19.4	6.6
Bleached sulfite	39	2.5	19.2	7.4	2.5	17.5	6.3
Bleached sulfite	189	1.25	46.6	12.2	1.25	42.0	10.3
Unbleached kraft	58	0.6	24.7	5.0	1.0	24.4	4.9
Unbleached kraft	58	1.0	28.5	6.4	2.0	28.1	6.0

[a] Ream size = 25 × 40—500. [b] Mullen burst values rather than tensile. [c] Cationic urea-formaldehyde resin rather than melamine.

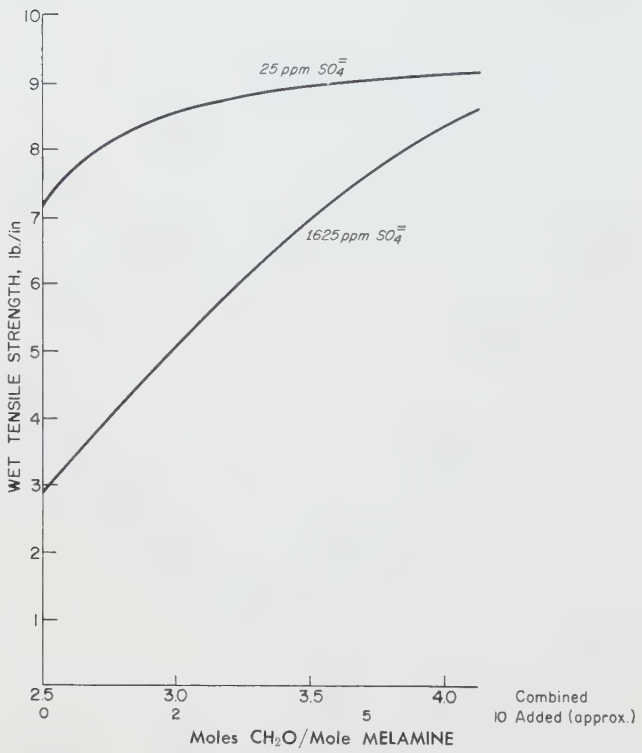

Fig. 3. Effect of combined CH_2O on wet strength

Two per cent colloid as MF_3 added in all cases.

Alum (1% on fiber) furnished 25 p.p.m. $SO_4^=$ in both cases, and sodium sulfate was added to obtain the high sulfate level. Unless otherwise noted, the stock was maintained at pH 4.5. These data are shown in Fig. 3.

Figure 4 illustrates the relative efficiencies of the regular and HE colloid under low sulfate conditions. The results are plotted as wet strength vs. resin added. The dotted lines show that 0.6% HE colloid gives the same wet strength as 1.0% regular, and that 1.1% HE gives the same wet strength as 2% regular. Similar comparisons under high sulfate conditions would of course show an even greater advantage from the use of HE colloid.

Although the data shown in the previous figures are based on laboratory studies the HE colloid is also economically more advantageous than the regular under mill conditions, with a few possible exceptions. In general, the cost of the extra formaldehyde is more than made up by the improved efficiency; under normal sulfate conditions, from 40 to 70 lb. of the HE colloid has proved to be equivalent to 100 lb. of regular colloid, or roughly a 100% improvement; under adverse sulfate conditions, the improvement in efficiency by switching to HE is in the order of 1000%. Table III shows the results of comparisons of HE and regular colloid in several commercially made papers.

Colloid Formulation

It should be noted (Fig. 3) that relatively small amounts of additional formaldehyde give a major improvement in efficiency if the anion concentration (e.g., sulfates) are low, but that much higher amounts are required to obtain high efficiency under adverse anion conditions. It is thus practical economics to prepare the colloid with optimum amounts of formaldehyde and of hydrochloric acid for the particular system involved. The suggested formulations for high- and low-sulfate conditions are given in Table IV.

COLLOID STABILITY

All melamine-formaldehyde colloids undergo further polymerization on storage, which can ultimately end in a gelled system. The known factors that affect the rate of gelation, besides the usual ones of resin concentration and temperature, are the melamine-to-formaldehyde ratio and the quantity of acid used. At any given acid content, the more formaldehyde, the faster the system gels. The melamine:HCl range which results in satisfactory colloids is limited and the optimum ratio varies with the amount of formaldehyde present. Because of poorer stability, it is recommended that the concentration of the HE colloids during preparation and storage be kept at 8 to 10% instead of the 12% recommended for the regular colloid. Figure 5 shows the keeping qualities of various colloids; the time-to-gel curves for regular and HE colloids at two acid levels are given.

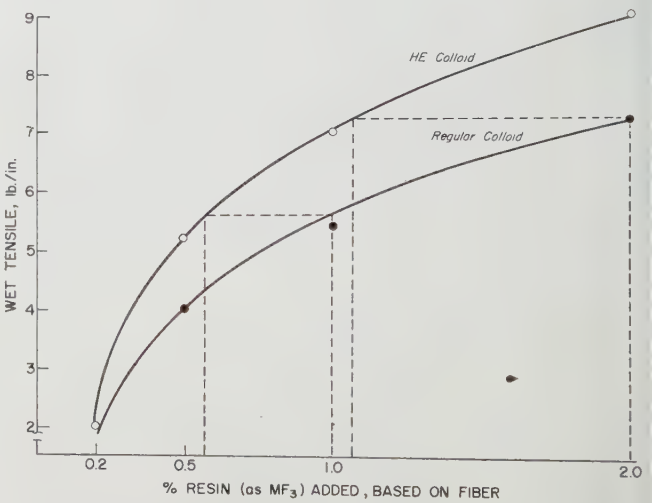

Fig. 4. Efficiency of HE colloid vs. regular colloid

pH 4. 5.

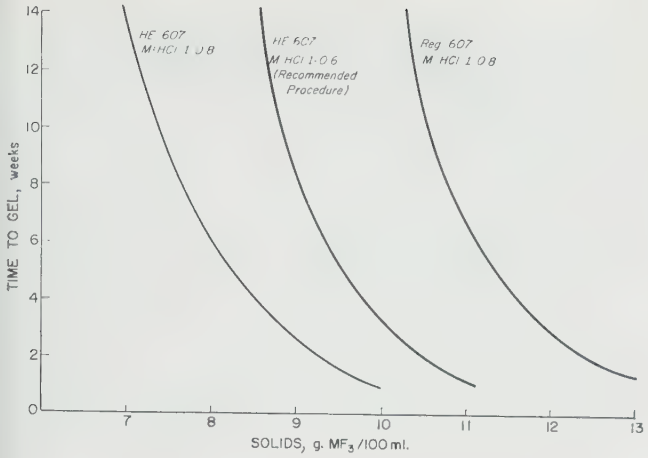

Fig. 5. Stability of melamine-formaldehyde colloids

Other than actual gelation, there is an efficiency advantage in the long-time storage of both regular and HE colloids at 8%. Colloids stored at higher solids tend to lose efficiency, particularly when used under high sulfate conditions.

MECHANISM OF CURE

Recently, evidence has been presented to show that the result of curing melamine and urea wet-strength resins in paper is the formation of resin-to-resin bonds rather than resin-to-cellulose bonds (*12, 15*). The HE colloid was not evaluated in this series but it is probable that the bonds in this case would also be resin-to-resin. Because of the greater efficiency of the HE resin these bonds must either be stronger or there must be more of them.

More bonds through improved resin retention was at first suspected but it soon became evident that resin retention, as determined by nitrogen analysis is invariably slightly *lower* when HE is used. Next it was assumed that the additionally combined formaldehyde was the key to better bonding and an experiment was made to check this hypothesis.

Table IV. Suggested Formulations for Various Melamine-Formaldehyde (MF) Colloids

	HE-5, high sulfate conditions	*HE-2½, low sulfate conditions*	*Regular*
Water (70 ± 20°F.), gal.	89	99	88
Hydrochloric acid (20°Bé), lb.	31	31	39
Formaldehyde (37%), gal.	20	10	...
Trimethylol melamine,[a] lb.	100	100	100
Total, gal.	120	120	100
MF_3 per gal., lb.	0.83	0.83	1.0
Approximate solids, % MF_3	10	10	12

The final solution should be allowed to age at least 3 hr. before using

[a] Sold commercially as Parez® Resin 607.

Comparable sets of handsheets were prepared with 2% HE and regular colloid. Some of the sheets were analyzed wet and others, after drying (and curing). The results (Table V) indicate that the resins in the wet sheets have about the same composition as the parent resin, but that the sheet containing the HE loses appreciably more formaldehyde during the drying cycle and develops the higher wet strength. This is evidence that extra bonds are formed where this formaldehyde splits off.

ANALYTICAL METHODS

Nitrogen Analysis

Melamine resin has a high nitrogen content. Assuming the absence of other nitrogenous materials, the melamine resin content of paper can be quantitatively determined by a simple Kjeldahl determination (*13*). To permit the use of the same procedure and same factor for converting nitrogen content to resin, all resin treatments referred to in this presentation have been based on trimethylol melamine irrespective of how much additional formaldehyde had been added.

Trimethylol melamine has a nitrogen content of 38.8%, or conversely a nitrogen factor of 2.6, which figure can be used for converting the per cent nitrogen found by analysis into per cent melamine resin.

Table V. Melamine:Formaldehyde (MF) Ratio in Dried and Undried Papers

Moles extra CH_2O added	*M:F mole ratio*	
	Undried sheets	*Dried sheets*
10	...	1:2.1
5	1:3.6	1:2.0
0 (Reg. MF_3)	1:2.4	1:1.9

Solids Determination

Solids by Oven Drying. It is always difficult to determine the solids content of thermosetting resin solutions by oven-drying because the "solids" change with degree of cure as more and more water-of-reaction is split off. However, with the regular colloid consistent values can be obtained that are uniformly less than the theoretical or calculated solids.

The HE products give less reproducible results. The loss of water-of-reaction is counterbalanced to various degrees not only by the weight of the extra combined formaldehyde, but also by the formation of uncombined paraformaldehyde in the dried product. Therefore, the oven method (*14*) is not recommended for the HE colloids.

Solids by Density Measurement. A simple hydrometer reading can be converted into solids, provided curves are first prepared of standard colloids made with the same formulation and from the same raw materials. Particular note should be made of the type of formaldehyde used as there are wide variations in methanol contents.

Solids by Refractive Index. An Abbé type refractometer can be used in place of a hydrometer, again provided that standard curves are first prepared.

SUMMARY

Melamine-formaldehyde colloids of improved effectiveness can be prepared by the addition of extra formaldehyde to the usual MF_3 resin, and adjusting the amount of HCl used to maintain the optimum pH (about 1.7) in the aged colloid. Lower pH conditions inhibit colloid development.

The improved (HE) colloid is less sensitive to sulfates than the regular; sufficient extra formaldehyde is used,

resulting in a colloid that is unaffected by the high sulfate conditions that are sometimes encountered in paper machine systems.

Evidence indicates that the HE colloidal particles contain appreciably more bound formaldehyde than do the regular—forced there by the mass action effect of the extra formaldehyde—and that the loss of this extra bound formaldehyde during the curing period accounts for the increased efficiency.

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Exploratory Pulping Studies with Full Chemical Processes.

JOHN R. PECKHAM and VINCENT VAN DRUNEN

A number of pulping processes were investigated on a laboratory scale with sprucewood as the raw material. Using sodium base, the pH range of an SO_2 system covered the levels found in acid sulfite (pH 1.4), bisulfite (pH 4.5), bisulfite–sulfite (pH 6.0), and sodium sulfite (pH 9.6), all at a constant ratio of 26.2% based on ovendry wood. In addition, two buffered sodium sulfite cooks were made, one at pH 10.7, achieved by the addition of sodium carbonate, and one at pH 12.0, obtained by the use of equal parts of sodium carbonate and sodium sulfide. Two kraft cooks were also made, one of which contained, in addition to sodium hydroxide and sodium sulfide, the neutral sulfite chemicals sodium sulfite and sodium carbonate. Two permanganate levels, *ca.* 12 and 20, were explored, and duplicate digestions were carried out at the lower permanganate number. Chemical analyses and physical properties of the pulps were determined. The test results had to be divided into two general categories, i.e., the four sodium-sulfur cooks and the alkaline cooks. In the first named, delignification became more difficult, and pulp yield dropped as the pH was increased. The bisulfite cook at the 20 permanganate number level was the brightest pulp produced in the study, but the other cooks in this series showed a definite trend toward decreasing brightness with increasing pH. The alkaline pulp yields were quite similar to each other, lower than those of the acid pulps, and the fibers were comparatively dark. The presence of sodium sulfide in any of the pulps seemed to limit brightness to under 35% G.E. The alkaline pulps were generally higher in pentosan and alpha-cellulose content than the acid pulps, while holocellulose contents were reasonably alike for all pulps. Viscosity was highest for the acid sulfite, lowest for the bisulfite-sulfite pulp. Pulp quality measured by the amount of tensile strength developed by the pulps on beating and the level of tearing strength at a given tensile, ranked the neutral sulfite–sulfide pulp best, followed closely by the kraft–neutral sulfite, kraft, and neutral sulfite pulps. The pulps of the sodium–sulfur system were all of poorer strength than the alkaline pulps and ranked, in descending order, sodium sulfite, acid sulfite, bisulfite, and bisulfite–sulfite. Pulp quality could not be directly correlated with any of the usually measured chemical properties of the pulps (viscosity, for example). However, a numeric value, which was the difference between holocellulose and the sum of alpha-cellulose and pentosan contents of a given pulp, was found to bear an inverse relationship to pulp quality.

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A satisfactory comparison of pulping processes is difficult to make because of a scarcity of data concerning a single wood species, where the pulping experiments cover a wide range of processes and the work is done under carefully controlled conditions. It is the purpose of this paper to report the results of experimental digestions carried out on sprucewood chips from a single source, using one specific collection of laboratory equipment and covering the pH range of *ca.* 1.5 to 13+.

Sodium was chosen as the base for the cooking chemicals because of the solubility of the various salts of this element. Thus, any combination of free sulfur dioxide, bisulfite, sulfite, bicarbonate, carbonate, sulfide, and hydroxide can be employed to cover the pH range from that of conventional acid sulfite to the kraft process.

RAW MATERIAL

Peeled spruce pulpwood bolts from the woodyard of the Interlake Mill of the Consolidated Water Power and Paper Co., Appleton, Wis., were carefully selected for uniformity of size and freedom from deformities. It was necessary to replenish the chip supply several times from this source.

The chemicals used to compound the cooking liquors were technical-grade sodium hydroxide, commercial

Table I. Test Methods Employed in Pulping Study

Sulfite pulping liquor analysis	TAPPI Method T 604 m-45
Permanganate number	TAPPI Method T 214
Brightness	TAPPI Method T 452 m-48
Beater evaluation	TAPPI Method T 200 m-45
Kappa number	Method of Tasman and Berzins (*1*)
Chemical analysis.	
Viscosity	TAPPI Method T 230 sm-50
Pentosans	TAPPI Method T 223 m-48
Lignin	TAPPI Method T 222 m-54
Holocellulose	(*2*)
Alpha-cellulose	(*2*)

sulfur dioxide, purified crystals of sodium sulfide and reagent-grade sodium sulfite and sodium carbonate. Appleton city tap water was used for dilution of the chemicals in all cases.

DESIGN OF EXPERIMENT

Several series of cooks were made in which the pH of the cooking liquor ranged from 1.4 to 13+. Wherever possible, i.e., in all but the kraft and modified kraft cooks, the total sulfur concentration, expressed as SO_2, in the cooking liquor, was held constant at 6.0%. Three permanganate number ranges were planned. The two which will be reported here are 11.5 ± 1.5 and 21.5 ± 1.5. A third sequence of cooks, designed to fall into the 30.5 ± 1.5 range, is still being investigated. Eventually, the work will also cover bleaching of the pulps comprising the two lowest permanganate number ranges.

Obviously, it was not possible to predict exactly the cooking conditions which would produce pulps of interest, so there were a number of pulps made which did not fit into the general picture. Since these experiments contribute little to the report, only those pulps which were kept for testing are described here.

The chemical tests used to characterize the pulps were permanganate number, Kappa number, viscosity, pentosan, lignin, holocellulose, and alpha-cellulose content. In addition, beater evaluations were made and sheet density, bursting strength, tear factor, tensile strength, and zero-span tensile were determined. Table I gives the various methods used in making the chemical and physical tests.

EXPERIMENTAL

The spruce bolts were chipped in a 48-in., four-knife Carthage chipper from which two knives were omitted. The chipper was set to deliver chips having a nominal length of $^3/_4$ in. The chips were screened on a 4-mesh screen and the through fraction was discarded, as were all large knots and slivers which could be removed manually. The accepted fraction was thoroughly mixed and packaged in equal-sized portions in kraft-glassine laminated sacks. Samples removed at this time were weighed, oven dried, reweighed, and discarded. The data concerning moisture content of the chips were used to calculate the weight of moisture-free wood per bag. Several batches of wood bolts were treated in the manner described above to provide the raw material for this study.

Pulping was carried out in a stainless steel digester of 44-liter capacity, fitted with a "Chempump" for circulation of the cooking liquor through a steam heat exchanger. Temperature changes were noted on a recording pyrometer, checked by reading a thermometer in an oil-filled well in the digester cover. Pressure readings were taken at regular intervals from a calibrated gage, and pressure was reduced to zero by gas relief at 100°C. A sample of black liquor was removed through a water-cooled condenser just prior to blowing.

The cooked chips and liquor were blown from the digester at the end of the cooking cycle, passing through a Cyclone separator and into a muslin-covered washbox. From the washbox, the drained pulp was transferred to a stainless-steel wash tank equipped with a perforated false bottom. Three consecutive dilutions were made with warm tap water, the first being agitated for 10 min. and the second for 5 min. with a Patterson Unipower stirrer. The third was not stirred. The effluent from the wash tank was directed onto a muslin-covered washbox, and any solids thus recovered were returned to the wash tank.

Table II. Cooking Conditions and Product Variables Replicate Pulping Study

Cook no. →	*18*	*1*	*19*	*6*	*20*	*8*	*23*	*9*	*24*	*10*	*22*	*12*	*17*	*11*	*21*	*16*
Type of cook →	*A Acid sulfite*		*B Bisulfite*		*C Bisulfite–sulfite*		*D Sodium sulfite*		*E Neutral sulfite*		*F Neutral sulfite–sulfide*		*G Kraft*		*H Kraft neutral sulfite*	
Max. temp., °C.	140	140	168	168	180	180	180	180	180	180	180	180	179	180	180	180
Time to max. temp., hr.	5.0	5.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5
Time at max. temp., hr.	2.5	2.5	3.0	3.0	8.0	8.0	10.0	10.0	10.0	10.0	9.0	9.0	2.5	2.5	1.25	1.25
Max. pressure, p.s.i.	85	85	180	180	180	180	126	128	134	136	136	142	133	136	126	..
Relief during cook	Yes	Yes	No	No	Yes	Yes	...	No	...	No	No	No	No	No	No	No
Total SO_2, %[a]	6.02	5.98	6.03	6.03	5.98	5.99	6.0	6.0	6.0	6.01	...	...	...	...	...	..
Free SO_2, %[a]	4.77	4.30	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$NaHSO_3$ (as SO_2), %[a]	1.25	1.68	6.03	6.03	5.95	5.63	...	...	...	...	...	...	...	...	...	...
Na_2CO_3 (as SO_2), %[a]	...	...	...	...	0.39	0.36	6.0	6.0	6.0	6.01	6.0	6.0	...	...	6.0	6.0
Na_2CO_3, %[b]	...	...	...	...	...	...	...	...	4.5	4.5	4.5	4.5	...	...	4.5	4.5
NaOH (as Na_2O), %[b]	...	...	...	...	...	...	...	...	...	...	...	...	13.5	13.5	13.5	13.5
Na_2S (as Na_2O), %[b]	...	...	...	...	...	...	...	...	...	...	4.5	4.5	4.5	4.5	4.5	4.5
pH of white liquor	1.4	1.4	4.5	4.5	6.05	6.0	9.7	9.7	10.6	10.3	11.9	11.8	...	13+	...	...
pH of black liquor	...	...	2.1	2.1	5.0	5.25	8.9	8.9	9.1	8.9	9.8	9.6	...	12+	...	...
Permanganate number[c]	12.6	12.5	11.1	10.6	12.0	11.0	12.5	11.8	11.3	11.6	10.5	10.0	12.1	10.9	10.8	9.9
KAPPA number		21		19		16		20		...		17		15.0		...
Unscreened yield, %	50.0	52.7	49.4	49.1	44.6	44.6	41.6	42.9	41.4	41.5	41.3	44.1	43.7	43.7	43.6	44.6
Screened yield, %	49.8	52.6	47.7	48.2	44.3	43.8	40.0	42.6	38.5	40.8	39.1	41.0	43.2	42.8	42.2	43.3
Screenings, %	0.4	0.3	3.4	1.9	0.8	1.7	3.9	0.7	6.8	1.6	5.5	6.95	1.2	1.9	3.2	3.03
G.E. brightness, unbleached pulp, %	56.1	58.0	34.8	38.7	45.0	37.2	49.1	48.5	47.4	...	33.0	34.9	28.1	30.6	36.6	40.4

Constant conditions: No. 4 stationary digester
Liquor ratio, cc./g. (ovendry wood) 4.7:1

[a] Concentration in white liquor. [b] Basis moisture-free wood. [c] TAPPI Method T 214 (25-cc. basis).

Table III. Cooking Conditions and Product Variables Median Permanganate Number Level Series

Cook no.[a] →	*29*	*A*	*40*	*B*	*41*	*C*	*42*	*D*	*35*	*E*	*37*	*F*	*28*	*G*	*39*	*H*
Type of cook →	*A Acid sulfite*		*B Bisulfite*		*C Bisulfite–sulfite*		*D Sodium sulfite*		*E Neutral sulfite*		*F Neutral sulfite–sulfide*		*G Kraft*		*H Kraft-neutral sulfite*	
Max. temp., °C.	140	140	160	168	178	180	178	180	176	180	176	180	176	180	172	180
Time to max. temp., hr.	5.0	5.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5
Time at max. temp., hr.	1.5	2.5	4.0	3.0	7.0	8.0	9.5	10.0	9.5	10.0	5.0	9.0	1.0	2.5	1.25	1.25
Max. pressure, p.s.i.	85	85	143	180	180	180	...	128	123	136	131	142	117	136	105	...
Relief during cook	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No
Total SO_2, %	5.98	6.00	6.04	6.03	6.07	5.98	6.0	6.0	6.0	6.0	6.0	6.0	...	...	6.0	6.0
Free SO_2, %	4.75	4.75	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$NaHSO_3$ (as SO_2), %	1.23	1.25	...	...	5.70	5.60	...	...	...	...	...	...	...	...	...	...
Na_2SO_3 (as SO_2), %	...	...	6.04	6.03	0.34	0.38	6.0	5.96	6.0	6.0	6.0	6.0	...	...	6.0	6.0
Na_2CO_3 (based on O.D. wood), %	...	...	...	...	...	...	...	...	4.5	4.5	4.5	4.5	...	...	4.5	4.5
NaOH (as Na_2O), (based on O.D. wood), %	...	...	...	...	...	...	...	...	...	...	...	...	13.5	13.5	13.5	13.5
Na_2S (as Na_2), (based on O.D. wood), %	...	...	...	...	...	...	...	...	...	...	4.5	4.5	4.5	4.5	4.5	4.5
pH of white liquor	1.4	1.4	4.4	4.5	6.0	6.0	9.6	9.6	10.7	10.4	12.0	11.8	13+	13+	12+	12+
pH of black liquor	2.0	2.0	3.0	2.1	5.15	5.12	8.3	8.9	9.1	9.0	10.0	9.7	12+	12+	12+	12+
Permanganate number (TAPPI Method 214)																
25-cc. basis	19.9	12.5	...	10.8	...	11.5	...	12.2	18.9	11.4	18.1	10.2	19.9	11.5	...	10.5
40-cc. basis	22.9	...	20.9	...	21.7	...	23.6	...	21.3	...	19.9	...	21.2	...	20.2	...
KAPPA number	39.4	...	36.5	...	35.7	...	39.0	...	34.9	...	31.2	...	34.9	...	29.6	...
Unscreened yield, %	53.3	51.4	50.3	49.2	46.8	44.6	45.0	42.2	47.1	41.4	49.3	42.7	48.8	43.7	45.9	43.6
Screened yield, %	53.2	51.2	50.2	48.0	46.8	44.0	45.0	41.3	46.2	39.2	40.2	40.0	47.0	43.0	45.8	42.2
Screenings, %	0.2	0.4	.04	2.6	.04	1.2	.04	2.3	1.9	4.2	18.6	6.2	3.7	1.6	.04	3.1
G.E. brightness, unbleached pulp, %	52.7	57.0	56.2	36.8	46.3	41.0	43.6	47.4	44.9	...	32.5	34.0	27.6	29.4	31.8	38.5

[a] The lettered cooks give average values for the duplicate digestions made at low permanganate number.

The washed and drained pulp was screened on a small Valley flat screen fitted with 0.010-in. slotted plates. Rejects were removed, oven-dried, weighed, and discarded. These weights were used to compute "screenings" which are expressed as a percentage of the unscreened pulp. The accepted fraction was caught in a tank identical with the wash tank previously described. The drain from this tank delivered its stream into a muslin-covered washbox to capture entrained fiber. The drained pulp was transferred to a screen-lined laundry-type centrifuge for thickening. The expelled water fell into a muslin-covered washbox for recovery of fines, which were returned to the centrifuge. After dewatering, the pulp cake was broken to bits mechanically and the pulp crumbs were packed in tared polyethylene bags. Representative samples were removed during the bagging operation for permanganate number and moisture determinations. Yield data were obtained from the wet weight of the pulp and its ovendry content. The unscreened yield, which includes all fractions, is expressed as a percentage of the moisture-free chips charged to the digester. The screened yield, which excludes the screening rejects, is reported on the same basis.

For purpose of convenience, the cooks are designated by arbitrarily assigned names and code letters. The terms are A—acid sulfite, B—bisulfite, C—bisulfite–sulfite, D—sodium sulfite, E—neutral sulfite, G—kraft, F—neutral sulfite–sulfide, and H—kraft–neutral sulfite.

Table II shows the cooking conditions and product variables for the sequence of pulps having a low permanganate number. The time–temperature relationship used in cook 1 was chosen from previous experimentation in this field. The liquor was compounded to test *ca.* 6.0% total and 1.25% combined SO_2, using TAPPI Method T 604 m-45 for analysis.

It is noted that the conventional way of expressing the makeup of an acid sulfite liquor leads to a singular amount of confusion when an attempt is made to describe acid liquors which are not rich in free SO_2. Because the Palmrose Method of analysis gives a fictitious value for free SO_2 in that $^1/_2$ of the combined SO_2 is included in this determination (see the note under "Combined SO_2" in the TAPPI Method), it has been convenient in the study to test for total SO_2 iodometrically and to describe the composition by reference to a graph of the dissociation of sulfurous acid (*see* Appendix I). Thus, while the conventional terms are used above, Table II is made up to show actual values.

Cook 6 was a successful effort to produce a pulp with a bisulfite liquor, pH 4.5. Under TAPPI methods of analysis, the liquor was said to have 6.03% total and 2.97% combined SO_2. Except for a possible trace of free or loosely combined SO_2, the liquor can be assumed to be a solution of sodium bisulfite.

Cook 8 utilized a liquor which was sulfited to a pH of 6.0. Analysis showed that the liquor contained 5.99% total SO_2. Equilibrium data for systems containing SO_2 would indicate that, at pH 6.0, the distribution of salts would be 5.63% SO_2 present as $NaHSO_3$ and 0.36% as Na_2SO_3.

Cook 9 was made with sodium sulfite dissolved in tap water. The liquor was made up to contain 5.99% total SO_2, and had a pH of 9.6. At a liquor ratio of 4.7 to 1, this chemical concentration was the equivalent of 55.4% Na_2SO_3, based on wood. Cook 10 was done in the same manner except that 4.5% sodium carbonate (basis of moisture-free wood) was added to the cooking liquor. The pH was thus raised to 10.3. It will be noted that, as the alkalinity of the liquors increased to where the SO_2 was all present as the sulfite, higher temperatures and longer times were needed to obtain the desired degree of delignification. The addition of sodium carbonate to the sulfite liquor, although it increased the pH somewhat, did not appear to retard the chemical reaction noticeably.

Cook 11 was a conventional kraft digestion, and here a reasonable amount of chemical was used with no

attempt to adjust the sulfur content to agree with that maintained in the previous cooks. In cook 12, the general conditions of cook 10 were employed but the same amount of sodium sulfide used in the kraft cook was added to the sulfite–bicarbonate cooking liquor and the time at maximum temperature was reduced by one hour.

Cook 16 contained a kraft cooking liquor the equivalent to that used in cook 11, in which was dissolved the amounts of sodium sulfite and sodium carbonate used in cook 10. Time at maximum cooking temperature was reduced to a very nominal 1.25 hr. to provide a pulp having a permanganate number of 9.9.

Because of the extent of the proposed study, duplicate digestions were to be considered only if replication was proved a necessity. To investigate the reproducibility of the experimental digestions, the cooks previously described were repeated. Cooks 17 through 24 duplicated cooks 11, 1, 6, 8, 16, 12, 9, and 10, in that order. The information concerning these digestions also appears in Table II.

Table III shows how the cooking conditions previously used were varied to adjust pulp permanganate numbers to *ca.* 20 for the third series of cooks. In most cases temperature was lowered and, on occasions, time at maximum temperature was also reduced. Appearing alongside the data are average values from the duplicate cooks to the lower permanganate number.

The pulps were beaten in a Valley beater, and handsheets made at appropriate intervals were tested for basis weight, caliper, apparent density, burst, tear, tensile, and zero-span tensile. The data are reported on the basis of airdry handsheets and a weight based on a (25 × 40—500)ream.

DISCUSSION OF RESULTS

The pulps produced at a low permanganate number were, in general, low in yield and screening rejects. The level of permanganate number was that of an easy bleaching, acid sulfite pulp, and, as such, was lower than generally considered practical for alkaline digestions. Cook 1, the acid sulfite pulp, had high yield, low screenings and high brightness. The bisulfite (pH 4.5) pulp of cook 6 utilized a higher maximum temperature and a shorter cooking time, was considerably darker than the acid sulfite pulp, higher in screenings and lower in overall yield. Use of a bisulfite–sulfite liquor of pH 6.0 (cook 8) required a further increase in maximum temperature to 180°C., and drastic lengthening of cooking time. The pulp was of about the same brightness as the bisulfite pulp, but was produced at about 5% less yield.

Sodium sulfite liquor, pH 9.6, required even more time at a temperature of 180°C. than the bisulfite–sulfite liquor, to produce an acceptable pulp (cook 9). Yield was low (42.9%), screenings were few, and the pulp brightness was about halfway between the bisulfite and acid sulfite pulps. The addition of sodium carbonate to the sulfite system, as done in cook 10, seemed not to shift the reaction rate materially.

The kraft cooking conditions used were drastic as far as maximum temperature was concerned. The yield was a little higher than those from the sodium sulfite and neutral sulfite cooks, 9 and 10, and the pulp was typically dark colored. When the same amount of sodium sulfide used in the kraft cook was combined with amounts of sodium sulfite and sodium carbonate such as used in neutral sulfite cook 10, the time necessary to pulp to the required permanganate number was shortened by about 10%, as shown in cook 12. Yield and screenings rejects were increased and brightness was considerably lower than was the case in cook 10. The liquor used to pulp cook 16 contained a full complement of both neutral sulfite and kraft cooking chemicals. The time at maximum temperature was only half that of the kraft cook and yields were comparable. The brightness of the pulp of cook 16 was approximately 10 points higher than that of the kraft pulp.

When the results of duplicate digestions are considered, Table II, it will be seen that kraft cooks 17 and 11 agreed well in all of the usual product variables. The second acid cook (18) had a lower yield than the original, but otherwise the two pulps seemed to match well. The bisulfite and bisulfite–sulfite cooks, at pH 4.5 and 6.0, were also in good agreement with the original pulps, with the exception that pulp brightnesses differed to some extent. All of the cooks containing sodium sulfite were within satisfactory limits in permanganate number, yield, and brightness.

The effect of higher permanganate number upon the yield and brightness of the pulps under study can be seen by the pairings in Table III. The average spread in yield in favor of the high permanganate numbers was 3.4% but varied from a low of 1.1 for the pH 4.5 pulp to 6.6% in the case of the neutral sulfite–sulfide pulp. The pulps made with acid liquors had quite high yields even at a low permanganate number level so it is perhaps not surprising that the spread is smallest among these pulps. The *ca.* 5% yield differences in the low and median permanganate number kraft pulps is a reasonable figure, based on past experimental work.

The highly alkaline pulps had low yields at low permanganate numbers, and, in general, recovered substantial amounts when pulping was terminated earlier in the cooking cycle. The single exception was the kraft-neutral sulfite pulp which did not change much more than the acid pulps.

Brightness changes which occurred between the same kinds of pulps of different permanganate number were generally in the expected direction. Kraft and acid sulfite pulps are generally expected to increase in brightness as pulping progresses and the two pulps in question followed the trend, though no great differences occurred. The pulps made with sodium sulfide were also less bright in the more highly delignified form. The pulps made at pH 4.5 and 6.0 might have suffered from lignin reprecipitation at the low permanganate numbers in view of the fact that they were much brighter at the higher permanganate number.

When the physical properties of the several pulps are compared, the usual lack of a good yardstick is noted. A glance at the data concerning the first series of cooks (Table IV) allows the use of broad generalizations. The highly alkaline pulps beat slowly, the sodium sulfite pulps more nearly like the fast-beating acid pulps. The pulp made at pH 6 beat very rapidly, the acid sulfite only slightly faster than the pH 4.5 pulps. The use of maximum bursting strength

as a means of classifying the quality of the pulps indicates that the bisulfite–sulfite pulp (cook 8) was extremely poor, and that acid sulfite (cook 1) was somewhat better than the bisulfite (pH 4.5) pulp of cook 6. The kraft pulp (cook 11) was quite strong by this criterion, about 40 points higher than the acid sulfite. The addition of neutral sulfite to kraft liquor (cook 16) seemed to increase strength somewhat, but the outstanding pulps were those where the cooking chemicals were predominantly sodium sulfite. Sodium sulfite without buffer (cook 9) was at least as good as the kraft–neutral sulfite pulp and adding buffer (cook 10) caused a large increase in maximum bursting strength. The cook containing sodium sulfide in addition to buffered sulfite (cook 12) was about as strong as the pulp of cook 10.

The maximum bursting strength developed has drawbacks as a means of comparing pulps. It does not differentiate between a pulp which develops its maximum strength early in the beating cycle and one which does so at a very low freeness value. A comparison of pulp properties at some agreed-upon level of freeness, in a useful papermaking range, might be more meaningful. Table V shows such a comparison, using 650 cc. Schopper-Riegler as the reference point because it catches many of the pulps at nearly maximum tensile strength. Bursting and tensile strengths at this freeness level agree quite well in ranking the sodium sulfite pulps highest, followed by the kraft type pulps, the acid sulfite, bisulfite and, a poor last, the bisulfite–sulfite pulp. The actual rankings are shown in Table VI.

It is acknowledged simplification to assume that pulp properties are compounded from an amalgam of fiber strength and fiber bonding, since it is known that fiber length and fiber flexibility, at least, play major

Table IV. Physical Properties of the Low Permanganate Number Pulps—First Series

Cook no. →	*1*		*6*	*8*		*9*	*10*		*12*	*11*	*16*
Type of cook →	*A Acid sulfite*		*B Bisulfite*	*C Bisulfite–sulfite*		*D Sodium sulfite*	*E Neutral sulfite*		*F Neutral sulfite–sulfide*	*G Kraft*	*H Kraft–neutral sulfite*
Schopper-Riegler freeness, cc.	0[a]	875	860[a]	0[a]	860	860	0[a]	870	865	865	855
	5	845	845	5	835	845	20	825	840	835	835
	20	710	760	10	760	825	40	760	810	790	795
	35	485	560	20	450	820	60	580	755	660	730
	50	285	370	30	225	785	80	270	660	485	565
	..	...	...	40	...	685	100	...	530	330	400
	..	...	...	60	...	365	120	...	350	...	...
Basis weight (25 × 40—500, airdry), lb.	0	46.2	46.1	0	46.1	44.8	0	46.2	45.6	47.0	46.9
	5	44.6	44.7	5	45.7	46.1	20	45.9	45.8	44.8	45.3
	20	45.2	46.2	10	45.5	47.2	40	46.1	46.8	45.8	46.3
	35	44.3	45.0	20	45.8	45.7	60	45.8	46.8	45.5	46.1
	50	45.2	44.4	30	46.1	46.7	80	45.9	46.1	45.2	46.0
	..	...	...	40	...	46.5	100	...	46.8	46.3	45.7
	..	...	...	60	...	45.6	120	...	47.1	...	...
Caliper, mils	0	3.6	3.6	0	3.5	4.2	0	4.5	4.2	4.2	4.3
	5	3.2	3.3	5	3.2	3.8	20	3.3	3.4	3.2	3.4
	20	2.8	3.0	10	3.0	3.6	40	3.1	3.3	3.2	3.2
	35	2.6	2.8	20	2.8	3.3	60	3.0	3.2	3.0	3.1
	50	2.6	2.6	30	2.6	3.2	80	2.9	3.1	2.9	3.0
	..	...	...	40	...	3.0	100	2.9	3.0	2.9	2.9
	..	...	...	60	...	2.8	120	...	3.0	...	...
Apparent density (airdry basis weight, lb./caliper, mils)	0	12.8	12.8	0	13.2	10.7	0	10.3	10.9	11.2	10.9
	5	13.9	13.5	5	14.3	12.1	20	13.9	13.5	14.0	13.3
	20	16.1	15.4	10	15.2	13.1	40	14.9	14.2	14.3	14.5
	35	17.0	16.1	20	16.4	13.8	60	15.3	14.6	15.2	14.9
	50	17.4	17.1	30	17.7	14.6	80	15.8	14.9	15.6	15.3
	..	...	...	40	...	15.5	100	...	15.6	16.0	15.8
	..	...	...	60	...	16.3	120	...	15.7	...	...
Bursting strength, pt./100 lb. airdry basis weight	0[a]	67	62	0[a]	70	113	0[a]	121	78	77	68
	5	105	88	5	76	152	20	236	211	165	159
	20	142	121	10	82	174	40	264	248	181	184
	35	132	126	20	80	190	60	238	261	161	184
	50	117	121	30	75	197	80	202	262	175	197
	..	...	...	40	...	200	100	...	221	164	178
	..	...	...	60	...	194	120	...	205	...	...
Tear factor, tearing strength of 16 sheets, g./airdry basis weight, lb.	0	1.19	1.21	0	0.63	1.70	0	2.01	2.92	2.53	3.07
	5	0.96	0.98	5	0.53	1.32	20	1.18	1.59	1.36	1.43
	20	0.73	0.82	10	0.48	1.19	40	1.13	1.56	1.33	1.43
	35	0.63	0.73	20	0.44	1.07	60	1.05	1.54	1.23	1.28
	50	0.60	0.68	30	0.35	0.99	80	0.98	1.48	1.15	1.24
	..	...	...	40	...	0.95	100	...	1.37	1.04	1.14
	..	...	...	60	...	0.83	120	...	1.40	...	...
Tensile strength (calculated for a 45-lb. airdry basis wt. sheet), lb./in.	0	21.9	20.0	0	24.9	26.2	0	33.0	23.7	20.7	20.7
	5	28.0	27.8	5	26.0	33.5	20	40.9	41.1	39.3	38.5
	20	39.3	28.0	10	29.4	39.8	40	44.7	46.2	39.4	41.3
	35	38.2	35.5	20	29.9	43.7	60	48.1	45.6	42.0	44.7
	50	36.5	35.1	30	28.8	45.4	80	45.3	46.2	40.9	42.3
	..	...	...	40	...	44.5	100	...	43.9	41.6	44.0
	..	...	...	60	...	46.6	120	...	45.4	...	...
Zero-span tensile strength (calculated for a 45-lb. airdry basis wt. sheet), lb./in.	0	49.9	45.1	0	28.6	51.3	0	53.8	55.3	60.0	58.8
	5	50.8	48.4	5	26.8	60.1	20	59.6	66.3	64.4	63.3
	20	49.1	53.7	10	31.4	57.8	40	61.9	65.4	66.0	65.2
	35	44.6	51.2	20	32.1	58.4	60	59.4	63.6	67.0	63.8
	50	42.8	43.8	30	31.9	61.4	80	57.2	59.5	62.7	63.7
	..	...	...	40	...	62.1	100	...	58.4	63.3	62.4
	..	...	...	60	...	58.6	120	...	60.0	...	...

[a] This column is beating time in minutes.

Table V. Comparison of the Physical Properties of Low Permanganate Number Spruce Pulps—First Series at 650-cc. S.-R. Freeness

Cook no. →	*1*	*6*	*8*	*9*	*10*	*12*	*11*	*16*
Type of cook →	*A Acid sulfite*	*B Bisulfite*	*C Bisulfite–sulfite*	*D Sodium sulfite*	*E Neutral sulfite*	*F Neutral sulfite–sulfide*	*G Kraft*	*H Kraft–neutral sulfite*
Beating time, min.	26	29	15	43	54	82	61	71
Apparent density (airdry basis weight, lb./caliper, mils)	16.5	15.9	15.8	15.8	15.2	15.1	15.2	15.3
Bursting strength, pt./100 lb. airdry basis weight	140	127	82	198	250	260	180	190
Tear factor, tearing strength of 16 sheets, g/airdry basis weight, lb.	0.68	0.76	0.46	0.94	1.06	1.48	1.22	1.27
Tensile strength (calculated for a 45-lb. airdry basis wt. sheet), lb./in.	39.8	34.7	29.5	46.1	47.8	45.8	42.0	43.7

Table VI. Comparative Ranking of Spruce Pulps at 650 cc. S.-R. Freeness

Cook series →	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
$KMnO_4$ number, ca. →	*12*	*12*	*20*	*12*	*12*	*20*	*12*	*12*	*20*	*12*	*12*	*20*
Property →	*Tensile*			*Burst*			*Tear*			*Zero-span tensile*		
A—Acid sulfite	6	6	7	6	6	7	7	6	6	7	4	4
B—Bisulfite	7	7	5	7	7	6	6	7	7	6	7	6
C—Bisulfite–sulfite	8	8	8	8	8	8	8	8	8	8	8	8
D—Sodium sulfite	2	4	4	3	4	5	5	5	5	4	6	7
E—Neutral sulfite	1	2	2	2	2	1	4	4	4	5	5	5
F—Neutral sulfite–sulfide	3	1	1	1	1	2	1	1	1	3	2	3
G—Kraft	5	5	6	5	5	4	3	2	2	1	1	1
H—Kraft–neutral sulfite	4	3	3	4	3	3	2	3	3	2	3	2

parts in handsheet strength. Such an assumption, however, allows a rationalization of the changes in fiber properties observed in this investigation. For example, it indicated that the sodium sulfite pulps obtain their greater bursting strength and tensile strength from a good bonding potential since the kraft-type pulps excel in zero-span tensile values, a measure of intrinsic fiber strength. The acid sulfite pulp had better bonding properties than the bisulfite pulp, since the fiber strength appears to be greatest for the bisulfite pulp. Intrinsic fiber strength is by far the lowest for the sulfite–bisulfite pulp.

To this point, tearing strength has been ignored. Generally speaking, the levels of tearing strength are expected to drop as tensile and burst increase, especially when refining action causes the changes in bursting and tensile strengths. Tearing values are visualized as being highest when, in the tearing area, fibers are long and interlocked and the bonds which join them fail when the sheet is stressed, causing the machine to expend energy pulling the fibers away from each other. As bonding increases, the initial inertial effect will tend to break fibers instead of bonds, and fibers which do pull away from each other may be shorter, thus lowering tearing strength. Based on this concept, it would be assumed that the kraft-type pulps would excel in tearing strength. Such pulps have high intrinsic fiber strength and it has been postulated that their bonding potential is not as high as that of the sodium sulfite class of pulps. With one exception, this appears to be true. At a given freeness level the kraft pulp (cook 11) and the kraft-neutral sulfite pulp of cook 16 have higher tear factors than the sodium sulfite pulps, cooks 9 and 10. Through some apparently optimum balancing

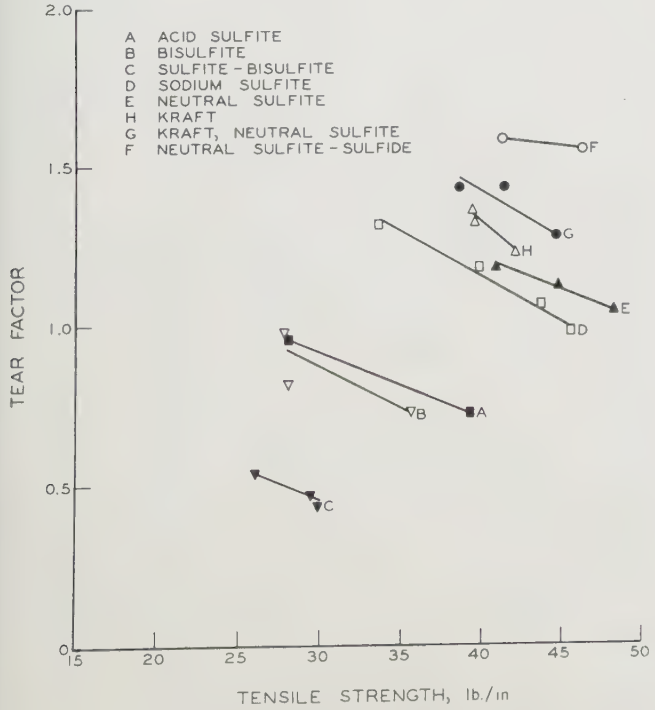


Fig. 1. Tear–tensile strength relationship of low permanganate number pulps of series 1

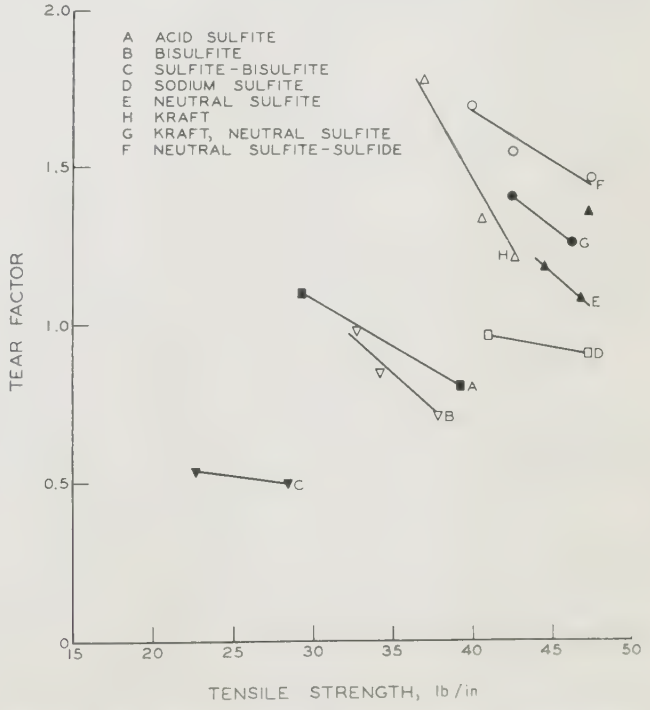


Fig. 2. Tear–tensile strength relationship of low permanganate number pulps of series 2

of fiber properties, the sodium sulfite-sodium sulfide pulp displays a substantially higher tearing strength at a given freeness than the two kraft pulps.

The acid types of pulp, with high bonding potentials and comparatively low levels of fiber strength, are, as predicted, low in tearing strength.

The relationship just discussed provides an opportunity to graphically describe the several individuals in this spectrum of pulps. In Fig. 1, covering the low permanganate number pulps, tear factor is plotted against tensile strength, ignoring the values for unbeaten pulps and discontinuing the curve at the point of maximum tensile. This appears to provide a useful relationship to study since the curves proceed in an orderly manner diagonally across the page. The extent of the progress of the curves toward the right shows the relative amounts of tensile strength developed in the various pulps and the tearing strengths at any given level of tensile strength can be quickly noted. The graph indicates, then, that the sulfite–bisulfite pulp is very poor, that the acid sulfite and the bisulfite pulps are similar in nature, with any advantage going to the pulp made by the more acidic process.

The sodium sulfite pulp, made without buffer, has good strength properties, as compared with the pulps made under acid conditions, but does not develop as much tearing strength as the more alkaline pulps. Adding buffer to the sodium sulfite liquor increases tearing strength at a given tensile strength level. The kraft pulp will not develop as high a tensile strength as the two sodium sulfite pulps, but tearing strength is shown to be quite high. Adding sodium sulfite and sodium carbonate to the kraft cooking chemicals gave a better tear–tensile relationship for this pulp than for

Table VII. Physical Properties of Spruce Pulps of Low Permanganate Number—Series Two

Cook no. →	*18*		*19*	*20*		*23*		*24*	*22*	*17*	*21*
Duplicate of cook →	*1*		*6*	*8*		*9*		*10*	*12*	*11*	*16*
Type of cook →	*A Acid*		*B*	*C*		*D Sodium*		*E*	*F Neutral*	*G*	*H Kraft–*
	—sulfite—		*Bisulfite*	*Bisulfite–*		*—sulfite—*		*Neutral sulfite*	*sulfite–sulfide*	*Kraft*	*neutral sulfite*
				—sulfite—							
Schopper-Riegler freeness, cc.	0[a]	855	850	0[a]	855	0[a]	850	845	860	845	850
	5	835	825	5	805	20	790	810	815	820	835
	20	690	740	10	650	40	580	720	775	705	765
	35	480	540	20	310	60	265	485	700	605	650
	50	345	355	30	155	80	125	250	585	455	485
	..	...	...	..	...	100	...	135	405	315	340
	..	...	...	..	...	120	...	...	260	...	...
Basis weight (25 × 40—500) airdry, lb.	0	46.5	46.5	0	45.3	0	47.0	46.1	47.0	46.3	48.1
	5	46.3	45.8	5	46.2	20	46.4	46.1	42.9	45.7	46.8
	20	45.5	46.1	10	46.3	40	46.2	46.7	45.9	45.8	47.1
	35	45.9	46.6	20	45.2	60	46.3	45.8	46.2	45.1	46.8
	50	47.6	46.4	30	46.7	80	47.3	46.6	47.0	46.1	46.2
	..	...	...	..	...	100	...	...	46.3	46.1	46.6
	..	...	...	..	...	120	...	...	46.4	...	...
Caliper, mils	0	3.6	3.7	0	3.4	0	4.1	4.2	4.1	4.2	4.2
	5	3.2	3.3	5	3.2	20	3.2	3.3	3.2	3.4	3.4
	20	2.8	3.0	10	2.9	40	3.0	3.1	3.2	3.2	3.2
	35	2.7	2.8	20	2.6	60	2.8	3.0	3.1	3.0	3.1
	50	2.8	2.8	30	2.6	80	3.0	2.9	3.1	3.0	2.9
	..	...	...	..	...	100	...	...	2.9	2.9	2.9
	..	...	...	..	...	120	...	...	2.9	...	...
Apparent density (airdry basis weight, lb./caliper, mils)	0	12.9	12.6	0	13.3	0	11.5	11.0	11.5	11.0	11.5
	5	14.5	13.9	5	14.4	20	14.5	14.0	13.4	13.4	13.8
	20	16.2	15.4	10	16.0	40	15.4	15.1	14.3	14.3	14.7
	35	17.0	16.6	20	17.4	60	16.5	15.3	14.9	14.9	15.1
	50	17.0	16.6	30	18.0	80	15.8	16.1	15.2	15.2	15.6
	..	...	...	..	...	100	...	...	16.0	16.0	16.1
	..	...	...	..	...	120	...	...	16.0	16.0	...
Bursting strength, pt./100 lb. airdry basis weight	0	62	73	0	73	0	115	111	79	69	71
	5	113	110	5	84	20	191	195	188	159	169
	20	145	131	10	84	40	199	211	217	170	201
	35	142	132	20	82	60	168	221	223	165	205
	50	131	129	30	72	80	162	179	230	167	192
	..	...	...	..	...	100	...	...	193	150	172
	..	...	...	..	...	120	...	...	186	...	...
Tear factor, tearing strength of 16 sheets, g./airdry basis weight, lb.	0	1.44	1.27	0	0.66	0	1.47	1.80	2.60	2.87	3.16
	5	1.10	0.98	5	0.54	20	0.97	1.19	1.70	1.78	1.41
	20	0.81	0.85	10	0.50	40	0.91	1.09	1.55	1.35	1.27
	35	0.74	0.71	20	0.44	60	0.82	1.05	1.47	1.22	1.24
	50	0.69	0.67	30	0.36	80	0.72	1.01	1.45	1.13	1.15
	..	...	...	..	...	100	...	...	1.32	1.13	1.03
	..	...	...	..	...	120	...	...	1.27	...	...
Tensile strength (calculated for a 45-lb. airdry basis weight sheet), lb./in.	0	21.6	25.1	0	21.6	0	31.1	28.7	23.1	20.0	22.5
	5	29.3	32.8	5	22.8	20	41.0	44.7	40.0	37.0	42.4
	20	39.3	34.1	10	28.4	40	47.2	46.9	42.6	40.7	46.3
	35	39.0	37.8	20	26.3	60	44.9	43.2	43.4	42.7	46.0
	50	35.6	34.0	30	24.9	80	43.0	44.2	47.4	40.4	45.7
	..	...	...	..	...	100	...	...	39.9	40.2	43.6
	..	...	...	..	...	120	...	...	43.8	...	...
Zero-span tensile strength (calculated for a 45-lb. airdry basis weight sheet), lb./in.	0	48.7	46.8	0	27.9	0	48.7	51.5	54.0	58.0	55.3
	5	54.5	48.2	5	28.5	20	49.0	54.1	57.0	60.6	59.6
	20	59.9	51.4	10	30.4	40	53.5	56.8	59.8	61.1	55.1
	35	56.0	48.6	20	30.2	60	53.8	54.6	62.2	63.0	59.7
	50	48.1	45.8	30	31.6	80	46.9	53.9	61.6	59.2	57.8
	..	...	...	..	...	100	...	...	57.7	59.4	55.1
	..	...	...	..	...	120	...	...	54.8	...	...

[a] This column is beating time in minutes.

a conventional kraft cook, but adding sodium sulfide to a conventional neutral sulfite cook produced a pulp which maintained tearing strength remarkably well while developing a high level of tensile strength.

When this point in the study had been reached, chronologically, a second set of cooks was made, duplicating the ones described above. A new supply of wood from the same general source was obtained and, as discussed previously, certain similarities and anomalies occurred in yield and color. Of greatest importance was the question whether the new group of pulps would duplicate the pattern of strength relationships described above. The strength properties, shown in Table VII, at first glance seemed to be in the same general relation to each other as had been observed in the first series of pulps. Comparing values at a given freeness level, it was found that duplicate pulps were, in some cases, quite far from exact matches. They did, however, rank almost exactly the same when their bursting, tensile, and zero-span tensiles were compared at a given level of freeness (*see* Table VI) A plot of tearing strength versus tensile strength

Table VIII. Physical Properties of Spruce Pulps

20 Permanganate number level

Cook no. →	*29*		*40*		*41*		*42*		*35*		*37*		*28*		*39*	
Type of cook →	*A Acid sulfite*		*B Bisulfite*		*C Bisulfite–sulfite*		*D Sodium sulfite*		*E Neutral sulfite*		*F Neutral sulfite–sulfide*		*G Kraft*		*H Kraft–neutral sulfite*	
Schopper-Riegler freeness, cc.	0[a]	870	0[a]	820	0[a]	820	0[a]	840	0[a]	870	0[a]	870	0[a]	870	0[a]	830
	5	855	10	740	2	765	10	805	10	850	10	855	20	840	10	790
	20	740	20	640	4	725	20	655	20	840	20	840	40	805	20	745
	35	545	30	500	6	630	30	370	40	760	40	815	60	750	40	670
	50	350	40	345	8	540	40	185	60	570	60	740	80	615	60	520
	..	...	..	...	10	395	..	...	80	315	80	620	100	430	80	360
	..	...	..	...	12	305	..	...	..	...	100	430	120	280	..	...
	..	...	..	...	..	...	..	...	..	...	120	275	...	...	..	...
Basis weight (25 × 40—500 airdry), lb.	0	46.2	0	46.0	0	46.7	0	46.6	0	46.2	0	47.0	0	45.5	0	46.4
	5	45.9	10	46.2	2	47.4	10	47.0	10	47.9	10	47.1	20	47.1	10	46.7
	20	46.1	20	46.7	4	46.5	20	46.7	20	46.4	20	47.1	40	46.6	20	46.4
	35	46.0	30	46.8	6	47.8	30	47.3	40	45.9	40	46.8	60	46.4	40	46.6
	50	45.7	40	47.0	8	47.0	40	46.9	60	46.4	60	45.9	80	46.5	60	46.9
	..	...	..	...	10	47.2	..	...	80	46.8	80	47.4	100	47.0	80	46.9
	..	...	..	...	12	46.7	..	...	..	...	100	46.4	120	46.1	..	...
	..	...	..	...	..	...	..	...	..	...	120	46.9	..	...	..	...
Caliper, mils	0	3.6	0	3.3	0	3.3	0	3.7	0	4.4	0	4.3	0	4.4	0	3.5
	5	3.3	10	3.1	2	3.3	10	3.3	10	3.8	10	3.7	20	3.5	10	3.3
	20	3.0	20	3.0	4	3.2	20	3.1	20	3.4	20	3.5	40	3.3	20	3.2
	35	2.8	30	2.9	6	3.1	30	3.0	40	3.1	40	3.2	60	3.2	40	3.1
	50	2.7	40	2.9	8	3.0	40	2.8	60	3.0	60	3.0	80	3.0	60	3.0
	..	...	..	...	10	3.0	..	...	80	2.9	80	3.0	100	3.0	80	3.0
	..	...	..	...	12	2.9	..	...	..	...	100	3.0	120	2.8	..	...
	..	...	..	...	..	...	..	...	..	...	120	2.9	..	...	..	...
Apparent density (airdry basis weight, lb./caliper, mils)	0	12.8	0	13.9	0	14.2	0	12.6	0	10.5	0	10.9	0	10.3	0	13.3
	5	13.9	10	14.9	2	14.4	10	14.2	10	12.6	10	12.7	20	13.5	10	14.2
	20	15.4	20	15.6	4	14.5	20	15.1	20	13.6	20	13.4	40	14.1	20	14.5
	35	16.4	30	16.1	6	15.4	30	15.8	40	14.8	40	14.6	60	14.5	40	15.0
	50	16.9	40	16.2	8	15.7	40	16.8	60	15.5	60	15.3	80	15.5	60	15.6
	..	...	..	...	10	15.7	..	...	80	16.1	80	15.8	100	15.7	80	15.6
	..	...	..	...	12	16.1	..	...	..	...	100	15.5	120	16.5	..	...
	..	...	..	...	..	...	..	...	..	...	120	16.2	..	...	..	...
Bursting strength, pt./100 lb. airdry basis weight	0	65	0	120	0	78	0	140	0	65	0	63	0	59	0	112
	5	114	10	151	2	85	10	171	10	161	10	151	20	156	10	173
	20	141	20	145	4	87	20	175	20	194	20	189	40	183	20	187
	35	148	30	145	6	73	30	171	40	211	40	219	60	181	40	191
	50	129	40	127	8	90	40	177	60	224	60	222	80	187	60	205
	..	...	..	...	10	89	..	...	80	201	80	212	100	178	80	189
	..	...	..	...	12	89	..	...	..	...	100	194	120	164	..	...
	..	...	..	...	..	...	..	...	..	...	120	183	..	...	..	...
Tear factor, tearing strength of 16 sheets, g./airdry basis weight, lb.	0	1.23	0	1.00	0	0.58	0	1.22	0	2.29	0	2.83	0	2.99	0	1.88
	5	1.02	10	0.87	2	0.55	10	0.98	10	1.44	10	1.80	20	1.66	10	1.39
	20	0.87	20	0.81	4	0.54	20	0.97	20	1.29	20	1.66	40	1.46	20	1.34
	35	0.78	30	0.79	6	0.50	30	0.87	40	1.13	40	1.45	60	1.38	40	1.18
	50	0.68	40	0.77	8	0.49	40	0.72	60	1.06	60	1.35	80	1.31	60	1.17
	..	...	..	...	10	0.47	..	...	80	0.98	80	1.29	100	1.21	80	1.19
	..	...	..	...	12	0.43	..	...	..	...	100	1.25	120	1.11	..	...
	..	...	..	...	..	...	..	...	..	...	120	1.15	..	...	..	...
Tensile strength (calculated for a 45-lb. airdry basis weight sheet), lb./in.	0	22.3	0	30.5	0	25.0	0	30.7	0	18.7	0	20.0	0	19.5	0	28.1
	5	32.3	10	41.3	2	28.8	10	38.4	10	35.2	10	37.7	20	36.2	10	40.1
	20	38.2	20	41.1	4	30.8	20	41.3	20	41.8	20	41.6	40	43.7	20	39.0
	35	39.0	30	41.2	6	28.8	30	41.7	40	45.2	40	45.0	60	40.6	40	42.6
	50	39.9	40	38.2	8	29.4	40	44.0	60	48.4	60	48.1	80	42.7	60	45.2
	..	...	..	...	10	32.1	..	...	80	47.8	80	49.7	100	40.7	80	45.7
	..	...	..	...	12	30.4	..	...	..	...	100	46.8	120	43.9	..	...
	..	...	..	...	..	...	..	...	..	...	120	44.5	..	...	..	...
Zero-span tensile strength (calculated for a 45-lb. airdry basis weight sheet), lb./in.	0	54.9	0	52.0	0	28.7	0	46.5	0	49.9	0	51.8	0	60.6	0	53.3
	5	60.1	10	56.2	2	28.0	10	51.5	10	53.6	10	57.3	20	67.2	10	58.4
	20	59.8	20	52.2	4	30.8	20	53.5	20	55.6	20	59.2	40	63.0	20	64.1
	35	57.1	30	52.0	6	30.0	30	55.3	40	61.7	40	62.4	60	59.2	40	60.0
	50	56.2	40	51.2	8	32.4	40	49.3	60	60.3	60	61.8	80	63.3	60	61.7
	..	...	..	...	10	31.0	..	...	80	59.4	80	60.6	100	60.2	80	60.8
	..	...	..	...	12	32.0	..	...	..	...	100	59.6	120	56.8		
	..	...	..	...	..	...	..	...	..	...	120	56.0				

[a] This column is beating time in minutes.

Table IX. Chemical Properties of Spruce Pulps

Cook →	*1*	*29*	*6*	*40*	*8*	*41*	*9*	*42*	*10*	*35*	*12*	*37*	*11*	*28*	*16*	*39*
Type of cook →	*A Acid sulfite*		*B Bisulfite*		*C Bisulfite–sulfite*		*D Sodium sulfite*		*E Neutral sulfite*		*F Neutral sulfite–sulfide*		*G Kraft*		*H Kraft–neutral sulfite*	
White liquor pH →	*1.5*		*4.5*		*6.0*		*9.6*		*10.3*		*11.8*		*13+*		*13+*	
Viscosity, cp.[a]	41.08	63.4	8.94	16.2	2.94	3.4	5.69	8.1	6.91	12.0	18.7	48.7	10.54	29.3	15.0	24.7
Pentosans, %[b]	7.0	7.5	6.3	7.8	6.7	7.2	11.2	10.7	10.6	10.0	8.1	9.5	9.0	9.3	8.4	10.2
Lignin, %[c]	1.2	3.8	0.6	2.2	0.4	2.2	0.6	2.4	1.0	2.2	2.1	3.2	1.7	3.9	1.6	3.6
Holocellulose, %[d]	96.8	97.0	98.8	97.0	98.2	96.7	96.4	95.8	96.4	94.3	97.4	96.0	96.9	96.6	98.6	97.0
Alpha-cellulose, %[d]	78.4	79.2	78.8	78.2	55.9	62.2	74.8	74.0	77.0	75.8	84.9	82.5	80.7	80.4	81.6	77.8
Ash, %		0.71		0.68		0.88		1.17		1.05		0.91		0.67		0.81

[a] TAPPI Method T 230 sm-50. [b] TAPPI Method T 223 m-48. [c] TAPPI Method T 222 m-54. [d] Wise, *et al.* (*2*).

Fig. 2, showed that either set of data, or an average of the two sets, would continue to rank the pulps in the same way.

The third series of cooks was made at a permanganate number which was considerably higher than that of the first two series. The strength properties, obtained as previously described (shown in Table VIII), were compared with each other in the manner used for the lower permanganate number pulps.

Preparation of a table ranking the pulps in regard to burst, tensile, and zero-span tensile at 650 cc. S.-R. freeness (Table VI) indicated that in tensile and bursting strength, the neutral sulfite pulp of cook 35 (the equivalent of cooks 10 and 24) and the neutral sulfite–sulfide pulp of cook 37 (the equivalent of cooks 12 and 22) were equal in value, as indeed they had nearly been in the first two series of pulps. The higher permanganate number elevated the rankings of the alkaline pulps (kraft and kraft plus neutral sulfite), one position while dropping the moderately alkaline pulp of cook 42 at least one place. At the higher permanganate number the bisulfite pulp was slightly superior to the acid sulfite pulp in bursting and tensile strengths, where it had been slightly inferior at the lower permanganate number level. The bisulfite–sulfite pulp was again a poor last in all physical properties.

In the zero-span tensile strength test, increasing permanganate number did not materially affect the ranking of the alkaline pulps. The kraft pulp still led the group as it had in the other series, with the kraft-neutral sulfite and neutral sulfite–sulfide pulps close behind. At the higher permanganate number, the zero-span tensile strength of the acid sulfite pulp exceeded that of the neutral sulfite, bisulfite, sodium sulfite, and the bisulfite-sulfite pulps which finish in that order.

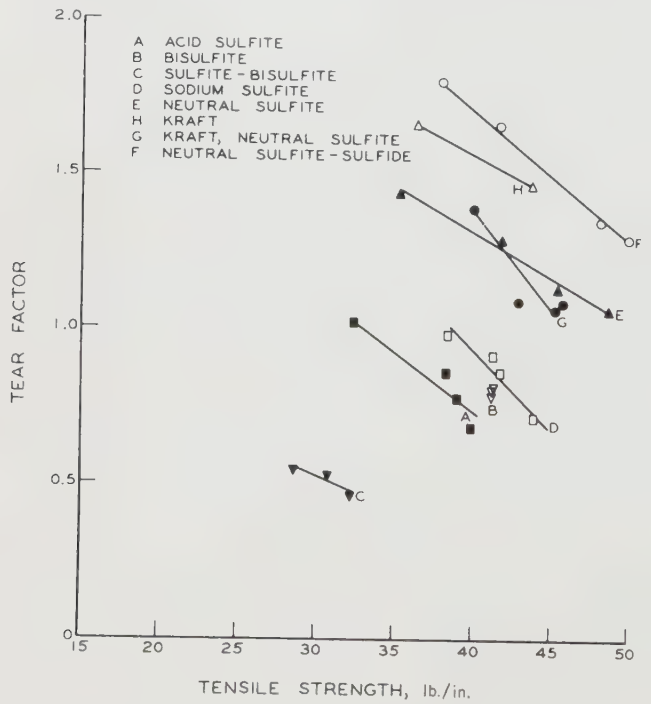


Fig. 3. Tear–tensile strength relationship of medium permanganate number pulps of series 3

When tensile–tear curves were prepared, Fig. 3, and superimposed on the previously referred to graphs, it was found that raising the permanganate number of the pulps did not cause them to shift their general positions in relation to each other. There were changes, however. At the higher permanganate number the bisulfite pulp (pH 4.5) improved more than the acid sulfite and the two pulps thus were almost identical in strength properties at this level of delignification. Also, the very lightly beaten bisulfite pulp exhibited almost as much tensile strength as was displayed after more complete beating. The sodium sulfite pulp (pH 9.3) was not as strong at permanganate number 20 as it was at permanganate number 12, and was only slightly better than the acid sulfite and the bisulfite pulps. Among the alkaline pulps, the kraft was improved substantially by decreasing the cooking, while the kraft-neutral sulfite pulp lost strength. The neutral sulfite pulp had lower initial tearing strength but appeared to develop more tensile strength and retain tearing strength better at the higher permanganate number. The neutral sulfite-sulfide pulp was again the outstanding pulp, developing a very high tensile strength and retaining good tearing strength at the same time.

The chemical properties of the pulps of series 1 and 3 were determined. The data, shown in Table IX, allow for generalizations in this respect, also. Viscosity, taken out of context, certainly has no linear relation to any other pulp property, either physical or chemical. If the acid and the alkaline pulps are considered separately, a loose sort of correlation can be pointed out. That is, with the acid pulps, cooks 1 and 6 are better pulps than cook 8 and have higher viscosities. But cook 1, which is quite similar in most respects to cook 6, has a viscosity which is 4 to 5 times higher. Among the alkaline pulps, viscosity and pulp quality are somewhat related, also. Here the amount of difference is more reasonable than in the acid pulps. As would be expected, the higher permanganate number pulps are higher in viscosity than the same kind of pulp in the low permanganate number bracket.

Lignin contents were found to be highest in the acid sulfite and kraft-type pulps, at both levels of delignification studied. The pulps not covered by this designation were about equal in lignin content.

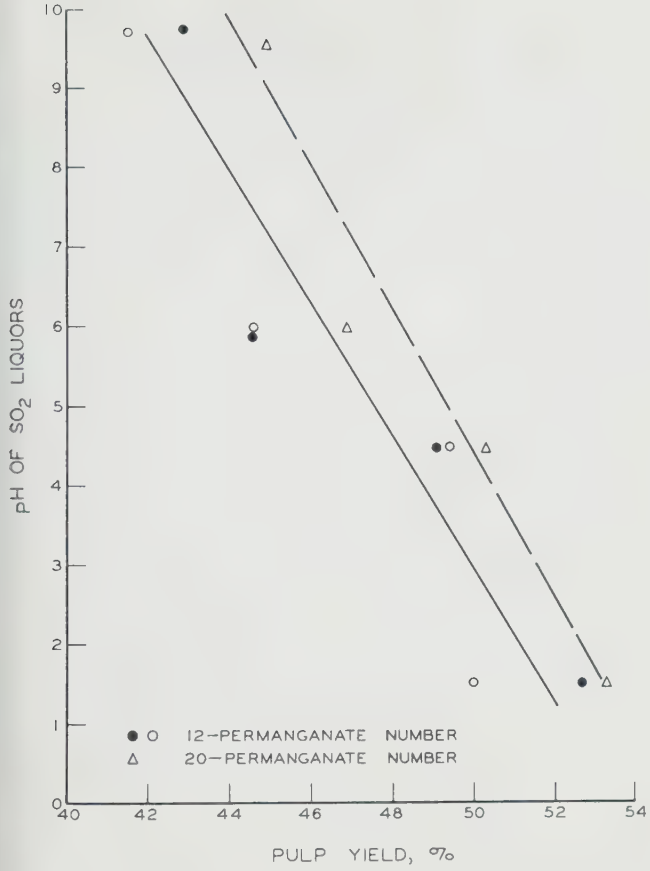


Fig. 4. Pulp yield as a function of cooking-liquor pH–sodium sulfite systems

In most cases holocellulose contents were reasonably similar for a given level of permanganate number, regardless of pulping method. The alpha-cellulose contents, however, varied considerably. In the low permanganate number series, the sulfite–bisulfite pulp has a very low alpha content, and the neutral sulfite–sulfide pulp has a high value. The acid sulfite, bisulfite, and neutral sulfite pulps are at roughly the same intermediate level while the two very alkaline cooks are somewhere close to the top. At the higher yield and permanganate number, the differences are not as extreme, but the general pattern is the same.

When a "pulp component" obtained by subtracting the sum of alpha-cellulose and pentosans from holocellulose was considered, it was found to have an apparent relationship with pulp quality. This "cellulose fraction" was highest in the degraded sulfite–bisulfite pulp and lowest in the sulfite–sulfide pulp. With some exceptions, the levels were quite closely associated with pulp quality as measured by the sum of tear and tensile or tear and bursting strength.

CONCLUSIONS

When spruce chips from the same general source were pulped by 8 different processes and the pulps were evaluated physically and chemically, the following conclusions were reached:

1. A change in batches of wood chips between duplicate digestions caused variations in pulp physical properties between the replicate cooks. This variation was not consistently in favor of either series, and the least amount of difference occurred in the cooks made from the least alkaline liquors. When pulp physical properties from each series of cooks were compared, it was found that the ranking among the several pulping processes was essentially the same.

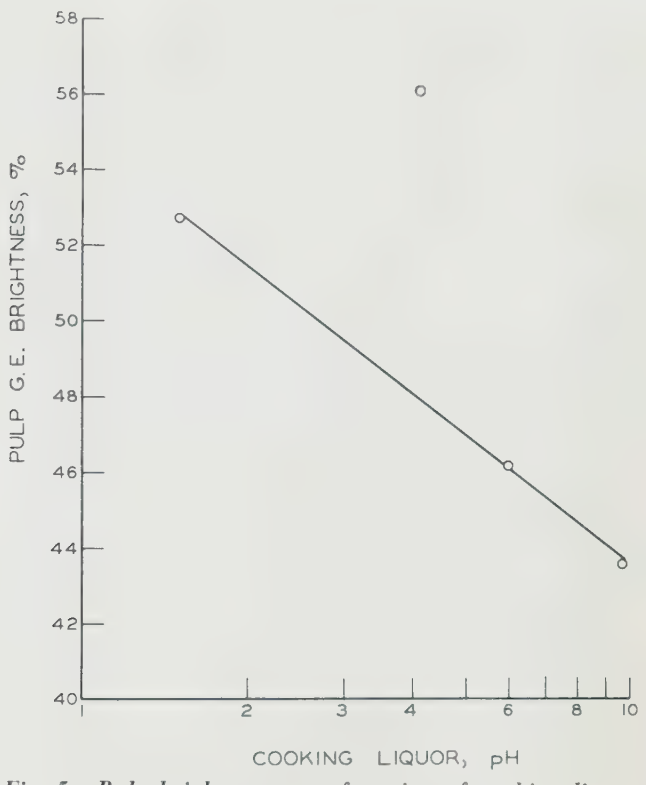


Fig. 5. Pulp brightness as a function of cooking-liquor pH–sodium sulfite systems

2. When a third series of pulps was made, this time at a higher permanganate number than characterized the first two series, the pulp yields increased and pulp brightnesses decreased in all but the bisulfite and sulfite–bisulfite pulps. The strength properties of the pulps, compared at the higher permanganate number, were in the same order of excellence, generally, as occurred in the low permanganate number pulps. The changes which were noted were shifts, not in comparative ranking, but in position, with the highly alkaline pulps showing strength improvement and some of the medium pH pulps some strength loss.

3. A comparison of the several pulping methods was made in terms of speed of reaction, pulp yield, color, chemical composition, and physical properties. The general conclusions were not altered by separate consideration of pulps made at low and medium permanganate number levels.

4. Pulps made with identical amounts of SO_2 at various pH ranges, with no associated chemicals, pulped more and more slowly as the starting pH was increased. Increase in pH caused by addition of buffering material (sodium carbonate) did not seem to continue this trend. The addition of sodium sulfide to a neutral sulfite chemical charge resulted in a definite acceleration of reaction. When sodium hydroxide entered the chemical system the reaction rates were those of the alkaline pulping processes and thus only a fraction of those common to the sodium sulfite system.

5. Pulp yields in the soda-sulfur systems containing no sulfide, carbonate, or hydroxide, decreased with increasing pH as shown in Fig. 4. At the elevated pH of the very alkaline cooks, pH was probably not a factor in pulp yield.

6. Pulp brightness in the low permanganate number range may not be effectively compared, since the long cooking times and high temperatures involved in attaining degree of delignification could have a major depressing effect upon fiber color. A comparison made at *ca.* 20 permanganate number shows that, in the SO_2 system, pulp brightness increases with decreasing pH, with one notable exception. The bisulfite pulp has a much higher brightness than predictable from the graph of brightness plotted against the log of pH, as shown in Fig. 5. Other brightness phenomena noted were (a) the substantial decrease when sodium sulfide was added to a neutral sulfite digestion, (b) the increase when sodium sulfite was added to a kraft cooking liquor, and (c) the fact that all of the pulps decreased in brightness when a lower level of delignification was employed, excepting the bisulfite and bisulfite–sulfite pulps. This may indicate that overcooking occurred at the lower permanganate number, with consequent reprecipitation of organic matter on the fibers.

7. While viscosity in cupriethylenediamine may be an effective way of measuring pulp quality between like cooks, the viscosity levels attained here appear to be strongly influenced by the cooking process.

8. Generally speaking, the acid (pH 6.0 and under) cooks had the least amount of pentosans. In the permanganate number ranges studied the two levels were about 7% for the acid as compared with 9.5 for the alkaline pulps. In both permanganate number levels observed, the pulp made with unbuffered sodium sulfite had the highest pentosan content.

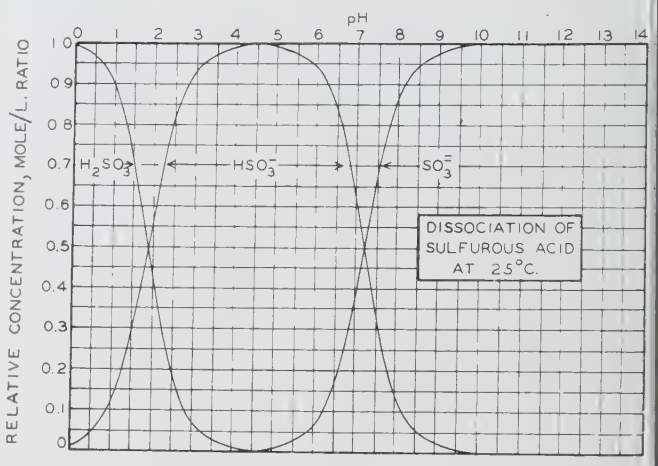
9. Among the acid pulps, at a given permanganate number, the acid sulfite pulps had about double the lignin found in the bisulfite and bisulfite–sulfite pulps. No particular trend could be noted in the alkaline pulps, although the kraft pulps were highest of the category on the average.

10. Alpha-cellulose contents of the pulps varied widely. The weakest pulp (bisulfite–sulfite) had by far the least, 55.9% at 10.6 permanganate number and the neutral sulfite–sulfide pulp the most with 84.9% at 11.8 permanganate number. Except for these two extremes, pulp quality could not be correlated with alpha-cellulose content.

11. When the sum of pentosans and alpha-cellulose is subtracted from the holocellulose content of the several pulps, the remaining "fraction" seems to bear some relationship to pulp quality. The linearity of the relationship depends upon the interpretation of the word "quality," since no single property correlates exactly. Some numeric value for the tear-tensile relationship would appear to be most suitable for use if the subject is pursued farther.

12. Several expressions of pulp quality characterizing the eight separate kinds of pulp made from spruce are compared in Table VI. From this we can conclude that by any criterion the bisulfite–sulfite pulp (pH 6.0) was the most degraded by the cooking process. In overall excellence, the neutral sulfite–sulfide pulp appears to rank first. It seems evident that the kraft process preserves the greatest proportion of the potential strength of the wood fibers. There would seem to be little doubt that the inclusion of a buffer improves the quality of pulps made with sodium sulfite solutions. Other relationships are not as clear-cut. The acid sulfite and the bisulfite pulps were very similar in most strength properties and kraft liquor containing neutral sulfite chemicals compared with straight kraft cooking had the effect of increasing fiber bonding at the expense of fiber strength. A graph of tear versus tensile strength over the useful freeness range, ranked the pulps in descending order of excellence: (1) neutral sulfite–sulfide, (2) kraft–neutral sulfite, (3) kraft, (4) neutral sulfite, (5) sodium sulfite, (6) acid sulfite, (7) bisulfite, and (8) bisulfite–sulfite.

APPENDIX I



Dissociation of sulfurous acid over a pH range from 0 to 10

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1. Tasman, J. E. and Berzins, V., *Tappi* 40: 691–695, 695–699, 699–704 (1957).
2. Wise, L. E., Murphy, M., and D'Addieco, A., *Paper Trade J.* 122, No. 2: 35 (Jan. 10, 1946).

Received November 18, 1960.

The design of this experiment originated with Donald J. MacLaurin and M. N. May. Their contribution to this research is gratefully acknowledged

Erratum

In the paper "Structural Weaknesses in Softwood Pulp Tracheids," by O. L. Forgacs, *Tappi* 44, No. 2: 112–119 (Feb., 1961), Fig. 3 is incorrect. The correct figure is shown below.

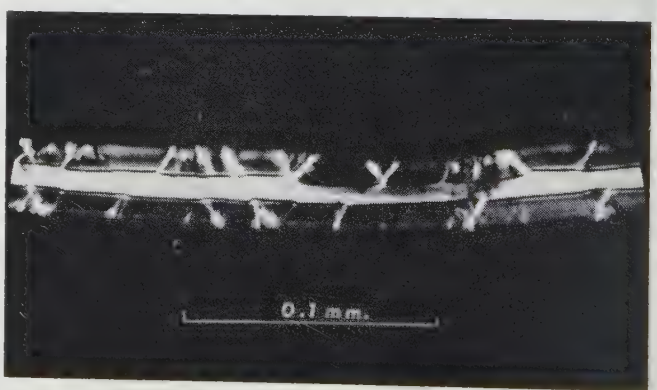


Fig. 3. Photomicrograph of the tracheid shown in Fig. 2, between crossed polaroid filters

ASSOCIATION NEWS AND EVENTS

National Conferences

1961

10th Statistics Course, June 19–30, Queens Univ., Kingston, Ontario.

Lignin Symposium, Aug. 14–16, 1961, Edgewater Beach Hotel, Chicago, Ill.

Twelfth Testing Conference, Aug. 15–18, 1961, Queen Elizabeth Hotel, Montreal, Que.

Eleventh Corrugated Containers Conference, Sept. 6–8, 1961, St. Francis Hotel, San Francisco, Calif.

Fourth International Mechanical Pulping Conference, Sept. 19–21, 1961, Edgewater Beach Hotel, Chicago, Ill.

6th Deinking Conference, Oct. 4–6, 1961, Hotel Harris, Kalamazoo, Mich.

Sixteenth Plastics-Paper Conference, Oct. 9–11, 1961, French Lick Sheraton Hotel, French Lick, Ind.

Sixth Engineering Conference, Oct. 15–19, 1961, Shoreham, Hotel, Washington, D. C.

Fifteenth Alkaline Pulping Conference, Nov. 1–3, 1961, Rice Hotel, Houston, Tex.

1962

47th Annual Meeting, Feb. 18–22, 1962, Commodore Hotel, New York, N. Y.

Thirteenth Coating Conference, May 14–16, 1962, Netherland-Hilton Hotel, Cincinnati, Ohio.

Thirteenth Testing Conference, Sept. 18–20, 1962, Benjamin Franklin Hotel, Philadelphia, Pa.

Seventeenth Plastics-Paper Conference, Oct. 8–11, 1962, Statler-Hilton Hotel, Boston, Mass.

Seventeenth Engineering Conference, Oct. 14–19, 1962, Queen Elizabeth Hotel, Montreal, Que.

Twelfth Corrugated Containers Conference, Oct. 23–26, 1962, Statler-Hilton Hotel, Boston, Mass.

Sixteenth Alkaline Pulping Conference, Oct. 31, Nov. 1–2, 1962, DeSoto Hotel, Savannah, Ga.

1963

Fourteenth Coating Conference, May 19–22, 1963, Concord Hotel, Kiamesha Lake, N. Y.

Thirteenth Corrugated Containers Conference, Oct. 22–25, 1963, Statler-Hilton Hotel, Detroit, Mich.

Eighteenth Engineering Conference, Oct. 28–31, 1963, Netherland-Hilton Hotel, Cincinnati, Ohio.

Other Associations

Osterreichische Vereinigung der Zellstoff- und Papier-Chemiker und-Techniker, Annual Meeting, May 18–19, 1961, Linz, Austria.

Papirindustriens Tekniske Forening, Scandinavian Pulp and Paper Engineers' Congress, May 29–June 2, 1961, Oslo, Norway.

Association Technique de l'Industrie Papetiére, XI Véme Congrés, May 29–June 3, 1961, Cannes, France.

Study Group of European TAPPI Members, Annual Meeting, June 12–15, 1961, Bruxelles, Belgium.

Zellcheming, June 27–30, 1961, Annual Meeting, Baden-Baden, Germany.

International Union of Pure and Applied Chemistry (IUPAC), Aug. 6–12, 1961, Annual Meeting, Montreal, Que.

Technical Section of the British Paper and Board Makers' Association, Sept. 25–29, 1961, Symposium: The Formation and Structure of Paper, Oxford, England.

Papirindustriens Tekniske Forening, Dec. 5–6, 1961, Technical Convention, Oslo, Norway.

A. S. Landers Joins TAPPI Staff

Albert S. Landers has joined the headquarters staff of the Association, according to a recent announcement by P. E. Nethercut, executive secretary. As supervisor of technical information Mr. Landers will direct the Association's Technical Information program designed to expand the present TAPPI Data Sheets to cover all areas of pulping, papermaking, and converting technology. In this capacity he will report directly to A. J. Winchester, technical secretary.

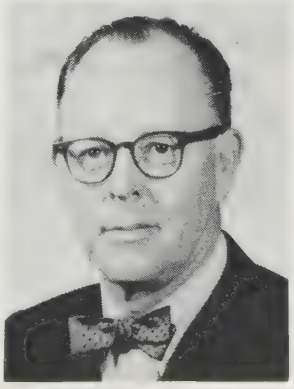
Mr. Landers has had broad experience in the paper and allied industries since graduating from the Department of Forestry at the University of Maine in 1937. He has been associated with Scott Paper Co., Reuben H. Donnelley Corp., Day and Zimmerman, Inc., Eastwood-Neally Corp., St. Regis Paper Co., Philadelphia Quartz Co., and Ron Deshazo and Co.

Rapidly changing factors in the paper industry have created many situations in which essential technical information is not readily available to mill personnel. The Technical Information program to be directed by Mr. Landers will include the compilation, authentication, and distribution of such material to TAPPI members. In this program Mr. Landers will work closely with the Association's eight divisions and 62 committees.

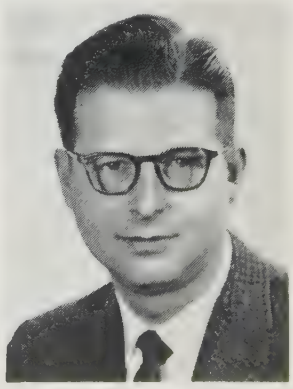
Graphic Arts Committee

Herbert J. Connell, S. D. Warren Co., Boston, Mass., was appointed chairman of the Graphic Arts Committee of the Coating and Graphic Arts Division of the Technical Association of the Pulp and Paper Industry, during the 46th Annual Meeting in New York, Feb. 20–23, 1961.

Other appointments included J. R. Gunning, Abitibi Power and Paper Co., Ltd., Sault Saint Marie, Ont., as secretary, and Alex Glassman, R. R. Donnelley & Sons, Co., Chicago, Ill., as technical officer.



Albert S. Landers, TAPPI



H. J. Connell, S. D. Warren Co., chairman Graphic Arts Committee

Tenth Statistics Course

The Tenth Statistics Course will once again be sponsored jointly by TAPPI and the Technical Section, Canadian Pulp and Paper Association and will, for the third time be held in Canada. The dates of the course are June 19 to 30, 1961, and the location will be Queen's University, Kingston, Ont.

Pulp and paper companies of every size are obtaining better control of quality, better uniformity of product, reduced material and testing costs, better engineering and research decisions, and other operating advantages through the use of modern statistical techniques. Thus, this course on statistical methods in the paper industry is aimed at meeting the industry's increasing needs in this field. Individuals participating in this course will improve their knowledge of and facility with statistical techniques to the ultimate benefit of their company and themselves.

Further details, application forms, etc. may be obtained by writing Mr. Douglas Jones, Executive Secretary, Technical Section, Canadian Pulp and Paper Association, 2280 Sun Life Building, Montreal 2, Que.

TAPPI-Sponsored Exhibit at 1962 Annual Meeting

In response to many requests in recent years by Sustaining Members, a trade exhibit under TAPPI auspices will be a feature of the 1962 annual meeting at the Commodore Hotel in New York.

The Commodore's spacious ballroom will be utilized as the exhibit area. It will accommodate some 70 individual booth units. Participation in the exhibit is limited to Sustaining Members.

Inquiries in connection with the exhibit should be directed to Jerome H. Brown, Exposition Manager, National Expositions Co., 107 East 38th St., New York 16, N. Y.

Monograph on Synthetic and Protein Adhesives for Paper Coating

A new monograph, entitled "Synthetic and Protein Adhesives for Paper Coating," has just beeen published by the Technical Association of the Pulp and Paper Industry (TAPPI), New York.

The publication is the 22nd in the TAPPI Monograph Series. It is a revision of Monograph No. 9 of the same title published in 1952 and was prepared under the direction of the TAPPI Coating Committee.

The monograph contains ten chapters dealing with the principles of adhesion, the manufacture of synthetic latices, styrene-butadiene latices, acrylic binders in paper and paperboard coatings, the butadiene-acrylonitrile latices, casein in paper coating, isolated soy proteins, and animal glue in coated papers. Nineteen authors in industry participated in compiling and writing the 272-page publication. It is a commentary on technical progress in the industry that a complete revision and rewriting of the text became necessary within a period of nine years.

The monograph has been written for the technical graduate. The day of the cookbook recipes for preparing coating formulations has long since passed. The future of coated paper rests as much in the hands of the physical chemist and the organic chemist as it does in the hands of the mechanical engineer who devises the techniques for physically applying the coatings to the surface of the body-stock. The higher level of our knowledge of this chemical phase of paper coating technology is strikingly revealed as one reads this new edition and then compares it with Monograph No. 9, its predecessor.

L. H. Silvernail, Dow Chemical Co., Midland, Mich., and W. M. Bain, Central Soya Co., Chicago. Ill., edited the monograph. The following TAPPI members and industry representatives were authors of the material contained in the monograph:

J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me.
S. Chandrasekaran, Polytechnic Institute, Brooklyn, N. Y.
H. Mark, Polytechnic Institute, Brooklyn, N. Y.
T. Alfrey, Jr., Dow Chemical Co., Midland, Mich.
J. Vitkuske, Dow Chemical Co., Midland, Mich.
R. G. Jahn, Dow Chemical Co., Midland, Mich.
H. R. Hall, Allied Paper Corp., Kalamazoo, Mich.
F. L. Schucker, Rohm & Haas Co., Philadelphia, Pa.
J. C. Rice, Lowe Paper Co., Ridgefield, Conn.
G. J. Antlfinger, B. F. Goodrich Chemical Co., Avon Lake, Ohio
H. K. Salzberg, Borden Chemical Co., Bainbridge, N. Y.
L. E. Georgevits, Borden Chemical Co., Bainbridge, N. Y.
R. M. Karapetoff Cobb, Lowe Paper Co., Ridgefield, N. J.
H. C. Schwalbe, Mead Corp., Chillicothe, Ohio
W. M. Bain, Central Soya Co., Chicago, Ill.
R. A. Olsen, Central Soya Co., Chicago, Ill.
S. J. Circle, Central Soya Co., Chicago, Ill.
R. Tutt, Jr., Peter Cooper Corp., Gowanda, N. Y.
L. B. Lane, Armour Alliance Industries, Alliance, Ohio

The publication is available at $3.00 per copy, and may be obtained from TAPPI, 360 Lexington Ave., New York 17, N. Y.

Indian Technical Association

An all India seminar on small-scale pulp and paper manufacture was held at Dalmianagar (Bihar) on March 18–20, 1961. It was attended by experts from all parts of the country. This occasion provided a good occasion for exchange of views on the long-felt need for a technical association of nonpolitical and noncommercial nature.

A meeting was held on March 19th which was atteneded by 200 representatives of companies in the pulp and paper industry. Sixty members of this group enrolled in the new organization. At this meeting the following members of the Council were elected:

Chairman—F. C. Michael, managing director, Titaghur Paper Mills, Ltd.
President—V. Podder, works director, Rohtas Industries, Ltd.
Council Members—
J. C. Aggarwala, mill manager, Bengal Paper Mills, Ltd.
B. D. Somani, director, West Coast Paper Mills, Ltd.
M. S. Parkhe, managing director, Pulp and Paper Conversions, Ltd.
R. P. Bhargava, manager, Star Paper Mills, Ltd.
N. K. S. Iyengar, development officer, Ministry of Commerce and Industry
S. N. Bhandari, Orient Paper Mills, Ltd.
M. L. Zutshi, Shree Gopal Paper Mills, Ltd.
M. D. Vijoy Raghawan, Dorr-Oliver (India), Ltd.

The president was empowered to appoint the executive secretary of the council. The following persons were appointed to membership of a subcommittee to frame the constitution of the association: F. C. Michael, V. Podder, and J. C. Aggarwala. It was voted by the members to name the organization "Indian Pulp and Paper Technical Association." It is expected that the objectives and mode of operation will be similar to organizations of the same type in other progressive countries of the world.

1961 CPPA-Technical Section Summer Conference

The 1961 Summer Meeting of the Technical Section will take the form of a conference on Chemical Pulping and Bleaching at Saranac Inn, New York, on June 7–9, 1961. The decision to hold a conference on a specific theme was taken in view of the many favorable comments received on the format of the 1960 Summer Meeting.

E. L. Neal, president and general manager of Gaspesia Pulp and Paper Co., Ltd., and 1961 chairman of the Technical Section, is general conference chairman. The program Com-

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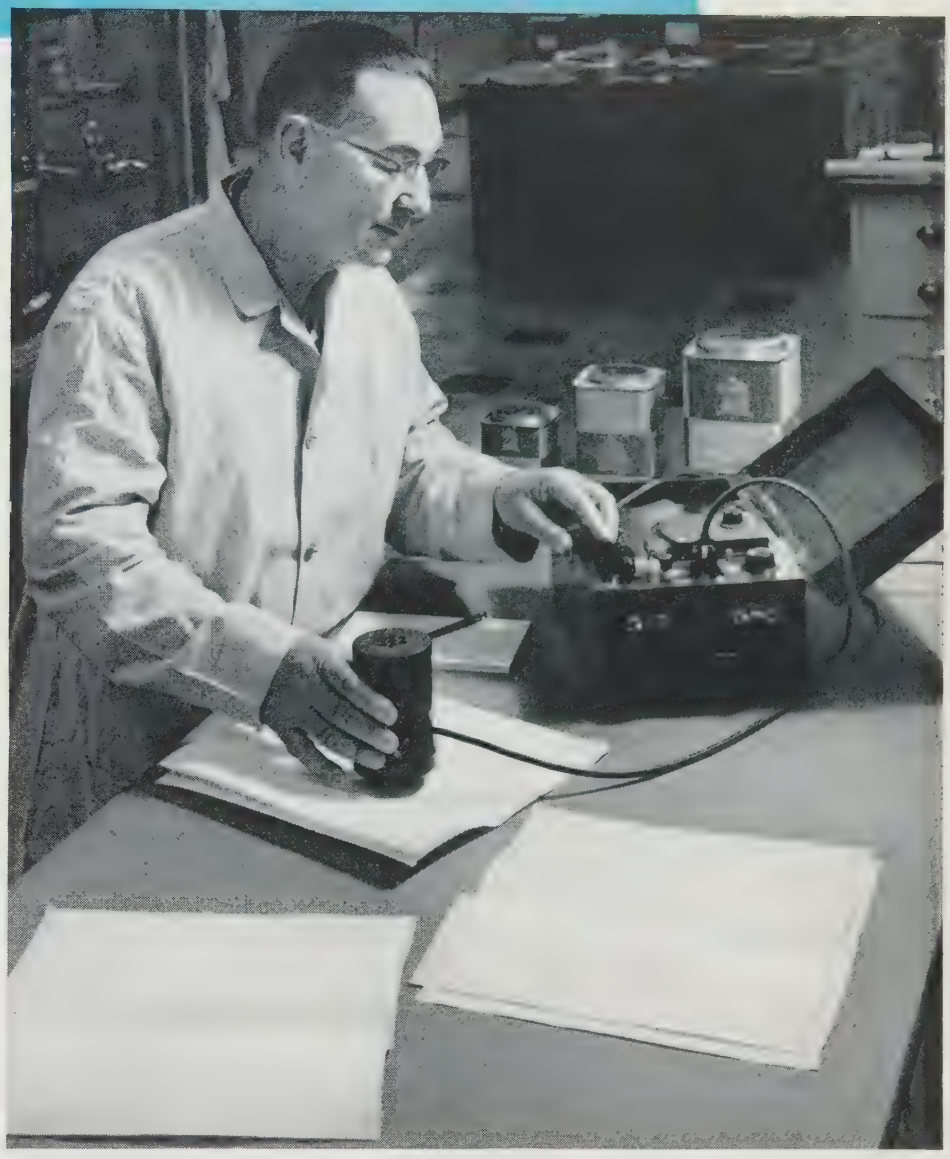

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mittee is under the chairmanship of W. H. Bush, Dryden Paper Co., Ltd., chairman of the Alkaline Pulping Committee and includes L. N. Stanners, Anglo-Canadian Pulp and Paper Mills, Ltd., chairman of the Sulfite Committee, and W. H. Rapson, University of Toronto, past-chairman of the Fundamental Research Committee.

The tentative program for the conference is given below.

SUMMER CONFERENCE ON CHEMICAL PULPING BLEACHING

WEDNESDAY MORNING, JUNE 7, 1961

General

1. Welcome Delegates: E. L. Neal, General Conference Chairman
2. Keynote Address: (to be announced)
3. Panel Discussion on the Future of Continuous Pulping for Kraft and Sulfite

WEDNESDAY AFTERNOON, JUNE 7, 1961

Research

1. "Chemical Aspects of Hypochlorite Bleaching," by J. H. E. Herbst
2. Effect of Chip Thickness on Sulfite Pulp Properties
3. (To be announced)
4. (To be announced)

THURSDAY MORNING, JUNE 8, 1961

Sulfite
New Recovery Processes

1. Soda-Base Recovery by Ion Exchange
2. Ammonia-Base Recovery by Ion Exchange
3. A Pilot-Plant Investigation of Ammonia-Base Recovery by Ion Exchange
4. (To be announced)

THURSDAY AFTERNOON, JUNE 8, 1961

Kraft

1. "Optimum Pulping Degree for Production of Softwood Bleached Kraft Pulp," by J. Chollet
2. Blowing Practices to Increase Pulp Strength (Panel Discussion)
3. Reducing Digester Corrosion—Problems in the Use of Stainless Steel Overlays (Panel Discussion)

THURSDAY EVENING, JUNE 8, 1961

Dinner—Speaker (To be announced)

FRIDAY MORNING, JUNE 9, 1961

Bleaching

1. "Reducing the Cost of Bleaching," by W. H. Rapson
2. Panel Discussion on Bleaching Costs

FRIDAY AFTERNOON, JUNE 9, 1961

General

1. Panel Discussion on the Cleaning and Screening of Chemical Pulp
2. Summary and Closing Remarks

Anyone wishing to present a paper at this conference is asked to contact W. H. Bush, Dryden Paper Co., Ltd., Dryden, Ont., or the Technical Section office, 2280 Sun Life Bldg., Montreal 2, Que.

For reservations at Saranac Inn, delegates should write to Tom Ward, reservations manager, Saranac Inn, New York, N. Y. Delegates should plan to arrive by Tuesday evening, June 6, since sessions will begin Wednesday morning. Rates will be as follows:

Singles (limited number):	$20.00 per day	American Plan
Doubles, two in a room, per person:	$17.00 & $18.00 per day	American Plan
Double Room for occupancy:	$25.00 per day	American Plan

The events will include a program for the ladies.

Wood Chemistry Symposium

A wood chemistry symposium will be held by the Pulp, Paper, and Board Division of IUPAC's Applied Chemistry Section in Montreal, Que., Aug. 9 to 11, 1961.

The symposium will take place during the Eighteenth International Congress of Pure and Applied Chemistry being held in Montreal in connection with the 21st Conference of the International Union of Pure and Applied Chemistry.

SESSION I

Session I, Wednesday, 2:00–5:00 p.m., August 9, will consist of the following papers:

Dr. Hans Meier, Svenska Traforsknings Institutet, Stockholm, Sweden, "Chemical and Morphological Aspects of the Fine Structure of Wood."

Professor K. Freudenberg University of Heidelberg, Heidelberg, West Germany, "Bogenesis and Constitution of Lignin."

Professor J. K. N. Jones, Queen's University, Kingston, Ont., "Biogenesis of Carbohydrates in Woods."

SESSION II

Session II, Thursday, August 10, 9:00 a.m. to 12:00 noon will offer the following papers:

Professor E. L. Hirst, University, Edinburgh, Scotland, "The Chemical Structure of the Hemicelluloses."

Professor Bengt Lindberg, Forest Products Laboratory, Stockholm, Sweden, "New Methods for Isolating Hemicelluloses."

Dr. Kyle Ward, Jr., The Institute of Paper Chemistry, Appleton, Wis., U.S.A., "Fractional Extraction of Hemicelluloses and Their Properties."

SESSION III

Session III will be held from 2:00–5:00 p.m., Thursday, August 10, with the following papers:

Dr. J. Mann, The British Rayon Research Association, Manchester, England, "Modern Techniques for Estimating the Crystallinity of Cellulose."

Dr. R. H. Marchessault, American Viscose Corp., Marcus Hook, Pa., "Applications of Infrared Spectroscopy to the Study of Cellulose and Wood Polysaccharides."

Professor A. H. Nissan, Rensselaer Polytechnic Institute, Troy, N. Y., "Cellulose as a Visco-elastic Polymer."

SESSION IV

Session IV, scheduled for 9:00–12:00 noon, Friday morning, August 11, offers the following papers:

Professor Kyosti Sarkanen, State College of Forestry, Syracuse, N. Y., "The Chemistry of Delignification in Pulp Bleaching."

Professor J. J. Hermans, State College of Forestry, Syracuse, N. Y., "Chemical Mechanisms in the Grafting of Cellulose."

Dr. D. A. I. Goring, Pulp & Paper Research Institute of Canada, Montreal, Que., "The Physical Chemistry of Lignins."

FINAL SESSION

Session V will take place 2:00–5:00 p.m., Friday, August 11, with the following papers:

Dr. J. K. Hamilton, Rayonier Incorporated, Shelton, Wash., "The Behavior of Wood Carbohydrates in Technical Pulping Processes."

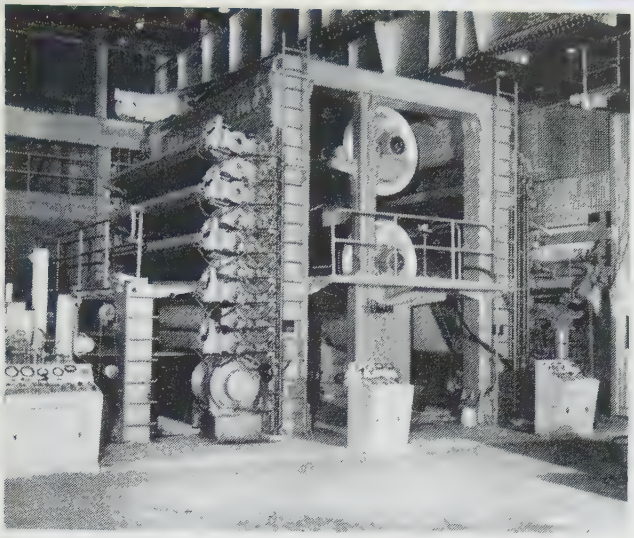
Professor Hennart G. Stockman, Swedish Cellulose Industry, Stockholm, Sweden, "Recent Developments and Present Trends in Technical Pulping Processes."

Professor T. Enkvist, University of Helsingfors, Helsingfors, Finland, "New Aspects on Lignin Reactions in Kraft Pulping."

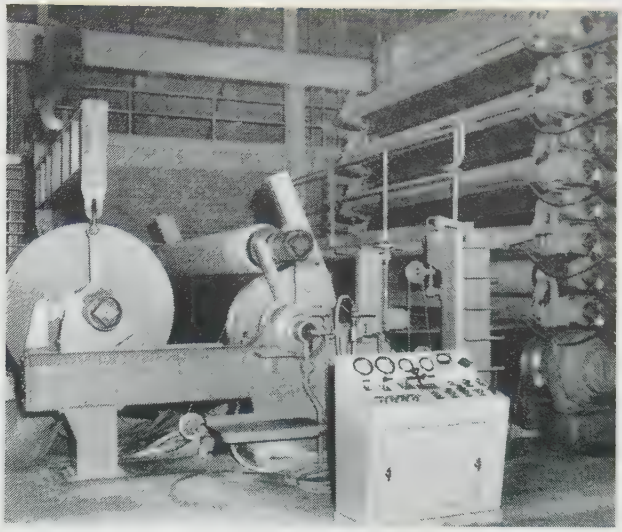
Those interested in attending should proceed quickly to reserve accommodations. The Congress will be held during the peak of the Montreal tourist season. It is essential to make reservations in advance.

General questions about the Congress should be addressed to: Chairman, Central Committee, XVIIIth International Congress of Pure and Applied Chemistry, National Research Council, Ottawa, Canada.

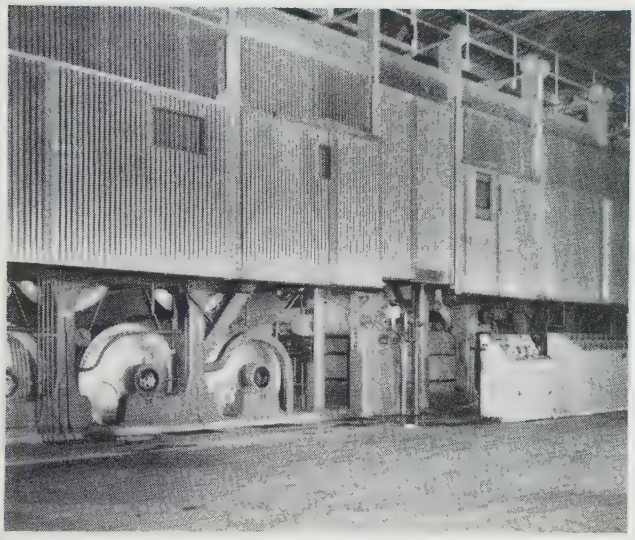
Specific questions concerning the wood chemistry symposium should be addressed to Professor Clifford B. Purves, chairman, Program Subcommittee, IUPAC, c/o McGill University, Montreal, Que.; or to Dr. Wilfred Gallay, chairman, Pulp, Paper & Board Division, IUPAC, c/o The E. B. Eddy Co., Hull, Que.



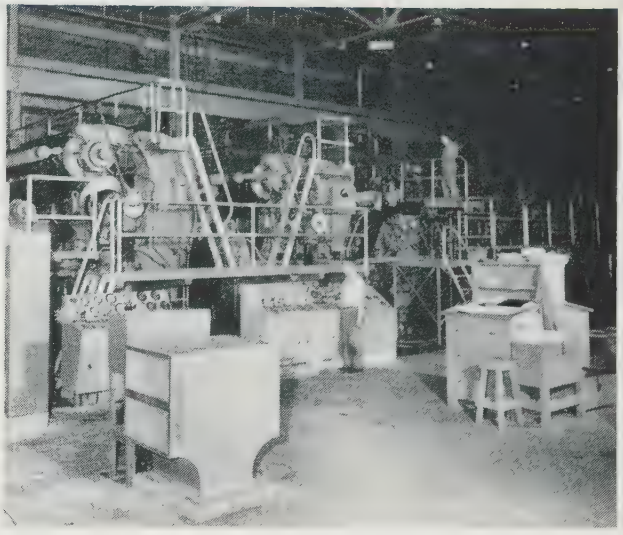
Double open-sided Calenders with inter-calender Dryers.



Constant Tension Reel.



Section of Dryer and Breaker Stack.



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TAPPI NOTES

High Lights of February Executive Committee Meeting

Association income during 1960 reached the record level of $820,000, which can be assigned roughly to the following sources: dues, 38%, advertising 37%, conference registration fees 13%, and sales of publications plus other sources of income 12%. This gratifying gain over 1959 income was more than offset, however, by 1960 expenditures of $859,000, resulting in an operating deficit of $39,000. Major classes of expenditures were publications 48%, divisions and committees (including conferences and project costs) 26%, and general administration 23%. The rising cost of printing various TAPPI publications contributed significantly to the operating deficit incurred during 1960.

"Regulations Governing Technical Information Sheets" were approved by the Executive Committee as a preliminary step to the initiation of the Technical Information Program.

The employment of A. S. Landers to direct this program is announced elsewhere in this issue. Full details on the Technical Information Program will be carried in "TAPPI Notes" in the June issue.

The Executive Committee reviewed the present statement of policy governing appropriations to support various committee proposals. President H. M. Annis will appoint a Research Advisory Council shortly to study the need for broader financial support of these programs.

Plans are being made for TAPPI sponsorship of the suppliers' exhibit at the 1962 Annual Meeting to be held in New York next February. The Grand Ballroom of the Commodore Hotel will be used for this purpose. Exhibitors will be company members of the Association.

The Executive Committee approved the establishment of a TAPPI Student Loan Fund to assist students preparing for technical careers in the pulp and paper industry. Details of this program will be worked out by a Student Loan Fund Committee to be appointed shortly.

Approval was given to a request from the Joint Career Guidance Committee for a TAPPI contribution of $1500 to the committee's working fund. This committee, composed of representatives from TAPPI, APPA, PIMA, NPA, and NPTA, will coordinate the recruiting activities of the various paper industry associations.

A 1961 APPA-TAPPI Research Conference has been scheduled, and a TAPPI grant of $5000 has been authorized by the Executive Committee. Like previous conferences of this type, it will bring chemistry and engineering professors together with paper industry technical leaders to discuss research problems of mutual interest.

A revised edition of the 1957 "Manual for the Guidance of Local Sections and Districts" will be published in the magazine, and reprints will be distributed shortly to all local sections and district officers. At the same time, the association staff will publish a Speaker's Directory to aid local section program chairmen in planning future meetings.

Distribution of the 1960 TAPPI Annual Bibliography will be restricted to those association members requesting a copy. A 1960 questionnaire on this subject indicated that many association members would not request a copy of the bibliography, if they were asked to do so. As a result of that survey, the TAPPI members are now being polled on their wishes concerning the 1960 edition to be distributed this summer.

Publication of the next edition of the TAPPI Yearbook will be delayed until January, 1962, resulting in an 18-month interval between printings. Copies of this new edition will be sent to all association members at that time.

The Executive Committee deferred until next fall further study of plans for a TAPPI charter flight to Europe. Consideration will be given at that time to a proposed 1962 flight enabling TAPPI members to visit various pulp and paper mills in Europe at much reduced transportation costs.

The appointment of members to various TAPPI special committees was announced by President H. M. Annis. Of these there are two committees whose chairmen are particularly anxious to receive appropriate suggestions from the association's membership.

The first is the Nominating Committee with J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me., as chairman. The Nominating Committee will prepare a slate of candidates for the 1962 offices of president and vice-president, and for the four new Executive Committee members.

The second is the Awards Committee, led by F. S. Klein, Byron Weston, Co., Dalton, Mass. It is the responsibility of this committee to recommend candidates for the TAPPI Medal.

Suggestions may be sent directly to these men or to the association office for transmittal to them.

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See Chemical Engineering Catalog for details and specifications.

TAPPI PROFILE

John C. Wollwage

JOHN C. WOLLWAGE, vice-president of the Technical Association, is general manager, Manufacturing Process, Consumer Products Division, Kimberly-Clark Corp., Neenah, Wis.

Born 47 years ago in Chicago, he early showed his ability by completing the Lane Technical High School in three years. In 1930, he entered Northwestern University in Evanston, Ill., and in 1934, at the age of 19, he received his B.S. degree in chemistry. His college summers were spent in Northern Michigan, teaching at boys' camps with the Chicago YMCA. While in high school he was runner up for the Junior National Archery Championship.

In 1934 he obtained a fellowship to The Institute of Paper Chemistry and received a Ph.D. from Lawrence College in 1938. His research work at the Institute was on the flocculation of papermaking fibers. In this work he developed techniques for observing flocculation in a flowing suspension, and studied the influence on flocculation of such additives as alum floc, deacetylated Karaya gum, and hydrophilic bentonite clay [*Paper Trade J.* 108, No. 12: 41–48; No. 13: 25–34 (March 23–30, 1939)].

By the time he joined Kimberly-Clark, in 1938, he had already gained some experience in the paper industry from summer jobs: in 1936 he worked in the research department of Hammermill Paper Co., Erie, Pa., and in 1937 he did research for Beveridge-Marvellum Co., Holyoke, Mass.

He first joined K-C as a research chemist in the technical department in Neenah, and worked mainly on the physical properties of paper—curl, stretch, and moisture content. He was superintendent of the technical department at the Lakeview mill, project leader in the technical department at Neenah and later, division head of the K-C War Production Board research-engineering unit. The War Production Board attempted to substitute paper for scarce and strategic materials, and the division headed by John Wollwage worked on the development of such items as disposable suits, low-cost camouflage, paper gasoline containers, and the reclamation of rubber and phenolic scrap materials.

Early in 1945 he became assistant mill manager at the Badger-Globe mill, and was named mill manager of Lakeview in April, 1946. Three years later he was appointed technical director of the corporation and later became manager and director of technical research. In 1955, he was named manager of the corporation's foreign operations and took charge of K-C's rapidly expanding subsidiaries in England, Australia, and South Africa. In addition, he helped start two new operations; one in Germany and the other in Mexico. He was appointed general manager, Manufacturing Process, Consumer Products Division in September, 1959.

John Wollwage has been a member of TAPPI since 1936, when he was on the Executive Committee of the Lake States Section. In 1952 he was a member of the Fundamental Research Committee, and in 1954 he was elected to the Executive Committee of the Technical Association. This February, at the 46th Annual Meeting, he was elected vice-president of TAPPI, and is now chairman of the Membership Services and Publications Committees.

He is also a member of the Technical Section of the CPPA, Sigma Xi, Phi Lambda Upsilon, and the ACS. He is listed in "American Men of Science" and in "Who's Who in the Business World." He is the joint holder, with John B. Catlin, of a patent on filter materials and process for making such materials.

He lives in Appleton with his wife, the former Jeannette Chabot, and their three boys, Paul, 19, David, 16, and Mark, 10. He is a director and member of the Executive Committee of the Valley Council, Boy Scouts of America; vice-president and director of the Appleton YMCA; and a former member of the Appleton Board of Education, and of the Appleton City Recreation Commission. He is also a member of the Appleton Riverview Country Club. For relaxation he still finds time for his favorite sports, golf and, very occasionally, tennis.

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1 day's supply of radium needles **$35**

1 instrument sterilizer **$50**

1 blood cell calculator, used in leukemia studies **$70**

3 units of human serum **$70**

4 days' maintenance of a cancer research bed.. **$100**

1 water phantom for radiation dosage studies.. **$100**

1 kymograph manometer **$134**

100 AK mice for preparation of Coombs serum **$150**

1 egg incubator **$150**

1 constant temperature bath **$200**

1 isotope scanner **$250**

1 x-ray tube **$480**

2,000 millicuries of radioactive iodine **$750**

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PERSONAL MENTION

New TAPPI Members

Ejvind Andersen, Technical Librarian, Danmarks Tekniske Bibliotek, Copenhagen, Denmark, a 1938 graduate of Danmarks Tekniske Hojskole.

Wilbur H. Barker, Assistant Technical Superintendent, St. Regis Paper Co., Tacoma, Wash., a 1948 graduate of University of Puget Sound.

Jule J. Baudhein, Sales Engineer, Lake Shore, Inc., Iron Mountain, Mich., a graduate of Michigan College of Mining & Technology.

Hedley C. Brideson, Principal Librarian, Public Library of South Australia, Adelaide, SouthAustralia.

Faunto Coggiola, Mill Manager, La Fibra Vulcanizzata e Cartiere Prealpine S.p.A., Milan, Italy.

Charles S. Connington, Jr., Sales Engineer, Lodding Engineering Corp., Auburn, Mass., a 1952 graduate of Amherst College.

Floyd L. Coons, Sales Representative, Morey Paper Mill Supply Co., Fitchburg, Mass., Attended S. W. Missouri State Teachers College.

Anthony T. Coscia, Chemist, American Cyanamid Co., Stamford, Conn., a 1956 graduate of New York University with a Ph.D. degree.

De Witt Davis IV, Research Associate, U. S. Gypsum Co., Chicago, Ill., a 1957 graduate of Williams College.

Francisco P. De Sousa, Chemical Engineer, Caima Pulp Co., Ltd., Albergaria a Nova, Portugal, a 1949 graduate of University of Oporto.

Italo Dorola, Factory Director, La Fibra Vulcanizzata & Cartiere Prealpine S.p.A., Milan, Italy.

Pio Elisei, Technical Manager, Stabilimento Poligrafico Buitoni, Perugia, Italy.

Tyler D. Evans, Technical Representative, Rohm & Haas Co., Wellesley Hills, Mass., a 1945 graduate of Princeton University.

Piero Fassio, Assistant Superintendent, Cartiera Italiana S.p.A., Torino, Italy, a 1951 graduate of University of Turin.

James H. Folsom, Student, University of Maine, Orono, Me.

Waldo J. Gates, Chemist, Certain-teed Products Corp., Paoli, Pa., a 1949 graduate of Washington University.

John Geraci, President and General Manager, Guard Chemical Co., Inc., Ossining, N. Y., a 1943 graduate of New York University.

Thomas P. Gibbons, Senior Project Engineer, Scott Paper Co., Chester, Pa., a 1960 graduate of Drexel Institute of Technology.

Georges, Gobert, Director, "La Papeterie," Paris, France. Attended University of Paris.

Luke H. Grace, Sales Representative, R. T. Vanderbilt Co., New York, N. Y.

Lyle J. Gross, Chemical Engineer, Vulcan-Cincinnati, Inc., Cincinnati, Ohio, a 1950 graduate of University of Colorado.

Alfred B. Grossauer, Production Engineer, Papierfabrik Gemmingheim GmbH, Gemmingheim/Wurtt., Germany, a 1958 graduate of Graz University, Austria.

Jordan H., Grubb, Technical Assistant to the Paper Mill Superintendent, St. Regis Paper Co., Jacksonville, Fla., a 1949 graduate of Abilene Christian College.

Melvin H. Hanson, Box Shop Superintendent, Continental Can Co., Inc., Hazel-Atlas Div., Oakland, Calif.

Roger T. Hefty, Technical Superintendent, The Rap-in-Wax Co., Minneapolis, Minn., a 1951 graduate of University of Wisconsin.

Bengt Hemberg, Manager of Research and Development, Stockholms Benmjolsfabriks AB, Stockholm, Sweden, a 1951 graduate of Royal Institute of Technology.

George E. Huber, Project Engineer, Continental Can Co., Inc., New York, N. Y., a 1927 graduate of Rensselaer Polytechnic Institute.

Robert H. Ingwall, Administrative Assistant, Virginia Smelting Co., West Norfolk, Va., a 1943 graduate of University of Rochester.

William E. Irwin, Market Research Supervisor, Miles Chemical Co., Div. of Miles Laboratories, Inc., Elkhart, Ind., a 1950 graduate of Western Michigan University.

Rolf Lie Kaaton, Chief Engineer, Alfsen OG Gunderson Ingeniorer, Oslo, Norway, a 1940 graduate of Technical University, Darmstadt.

Edward R. Kerwin, Application Engineer, General Electric Co., Bridgeport, Conn., a 1942 graduate of Manhattan College.

Rodolfo, Kollar, Paper Mill Manager, Cartiera Rossi S.p.A., Vicenza, Italy, a 1925 graduate of University of Zagreb.

Yasuo Kuroki, Engineering Director, Nippon Hardboard Industries Co., Ltd., Nagoya, Japan, a 1951 graduate of Kyoto University.

Neil J. Lasater, Assistant Chemist, Crown Zellerbach Corp., Camas, Wash., a 1958 graduate of Oregon State College.

Lester T. C. Lee, Research Chemist, Spaulding Fibre Co., Tonawanda, N. Y., a 1960 graduate of State University of N. Y. College of Forestry.

Richard G. Lenss, Sales Service Representative, Green Bay Paper & Pulp Co., Green Bay, Wis., a 1952 graduate of St. Norbert College.

Erik E. Lindvall, Research Manager, Fiskeby AB, Norrkoping, Sweden, a 1951 graduate of Royal Institute of Technology.

Peter C. Longjohn, Coating Chemist, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a 1959 graduate of Western Michigan University.

John W. Loraditch, Research Chemist, National Industrial Products Co., Keever Starch Div., Columbus, Ohio, a 1957 graduate of Ohio State University.

Peter J. McHale, Chief Chemist, General Cable Corp., Bayonne, N. J., a 1929 graduate of Pennsylvania State College.

Joseph N. Mease, Jr., Production Engineer and Shift Superintendent, Ledesma, S.A. Agricola Industrial, New York, N. Y., attended College of Charleston.

James D. Meeks, Director, Dallas Public Library, Dallas, Tex.

Edwin B. Morin, Chief Chemist, Berry Bros. Div., American-Marietta Co., Detroit, Mich., Attended Wayne State University.

Thomas G. Palsulich, Staff Engineer, Coca-Cola Export Corp., New York, N. Y., a 1935 graduate of New York University.

W. Lawrence Pennell, Production Superintendent, S. D. Warren Co., Muskegon, Mich.

Olavi Perila, Director, Graphic Arts Research Institute, Helsinki, Finland, a 1949 graduate of Technical University of Finland with a Ph.D. degree in 1956.

Kenneth M. Prytherch, Product Engineer, General Aniline &

Film Corp., New York, N. Y., a 1949 graduate of Massachusetts Institute of Technology.

Evadeen Rader, Library Technician, Pittsburgh Plate Glass Co., Barberton, Ohio.

Stuart H. Rider, Assistant Director of Research, Monsanto Chemical Co., Springfield, Mass., a 1944 graduate of Rensselaer Polytechnic Institute.

Emile A. Roy, Master Technician, Oxford Paper Co., Rumford, Me.

Georges Sauret, Engineer, Centre Technique De L'Industrie Des Papiers, a 1958 graduate of Bordeaux with a Ph.D. degree.

Edgar F. Sewell, Research Chemist, Peter Schweitzer Div., Kimberly-Clark Corp., Lee, Mass., a 1941 graduate of University of Maine.

J. Edward Sheehan, Engineer, Chas. T. Main, Inc., Boston, Mass.

Kitao Shimizu, Chief Engineer, Toyo Co., Ltd., Ehimeken, Japan, a 1947 graduate of Tokyo University.

Pierre Simonnet, Director, Papeteries Vincent Montgolfier Societe Anonyme, Charavines, Isere, France.

Homer M. Sinclair, Consultant, New Haven, Conn., a 1921 graduate of Carnegie Institute of Technology.

Wayne H. Smith, Training Director, St. Regis Paper Co., Pensacola, Fla.

Chamblin R. Smith, Process Chemical Engineer, Buckeye Cellulose Corp., Memphis, Tenn., a 1955 graduate of Georgia Institute of Technology.

Earl R. Sobeck, Engineer in charge of Paper Laboratory, Burroughs Corp., Plymouth, Mich., a 1959 graduate of Wayne State University.

Douglas W. Speed, Technical Service Representative, International Nickel Co., Huntington, W. Va., a 1957 graduate of University of Florida.

Timothy M. A. Tabb, Assistant Engineer, Bathford Paper Mills Co., Ltd., Somerset, England, a 1957 graduate of Oundle School, Northants.

Harry F. Thorn, Chief Engineer, Koppers Co., Inc., Bordentown, N. J., a 1942 graduate of Drexel Institute of Technology.

Malcolm H. Tinker, Sr., Sales Engineer, B. F. Perkins & Son, Inc., Holyoke, Mass., a 1933 graduate of U. S. Naval Academy.

Joseph C. Tu, Senior Scientist, Hawaiian Sugar Planters' Association, Honolulu, Hawaii, a 1942 graduate of Chinese National College of Pharmacy with a Ph.D. degree in 1951 from Purdue University.

Francis B. Weakley, Associate Chemist, U.S.D.A. Northern Regional Research and Development Div., Peoria, Ill., a 1942 graduate of St. Benedicts College.

Henry E. Wilt, Sales Engineer, Improved Machinery, Inc., Nashua, N. H.

James W. Wright, Project Engineer, Continental Can Co., New York, N. Y., a 1950 graduate of Stevens Institute of Technology.

Tom Y. C. Yang, Technical Director, General Felt Products, Div. Standard Packaging Corp., Brooklyn, N. Y., a 1948 graduate of University of Pittsburgh with a Ph.D. degree in 1950 from Columbia University.

Appointments

George F. Ackerman, formerly of Weyerhaeuser Co., is now Plant Manager of Southwest Forest Industries, Inc., Los Angeles, Calif.

Joseph J. Aid, Assistant Research Director of Continental Can Co., has been transferred from Uncasville, Conn., to Chicago, Ill.

William H. Aiken, formerly of Personal Products Corp., is now Director of Research and Development for Union Bag-Camp Paper Corp., New York, N. Y.

Pekka V. Alonen, formerly of Oulu O/Y, is now Pulp Mill Superintendent for Lohja-Kotka O/Y, Lohja, Finland.

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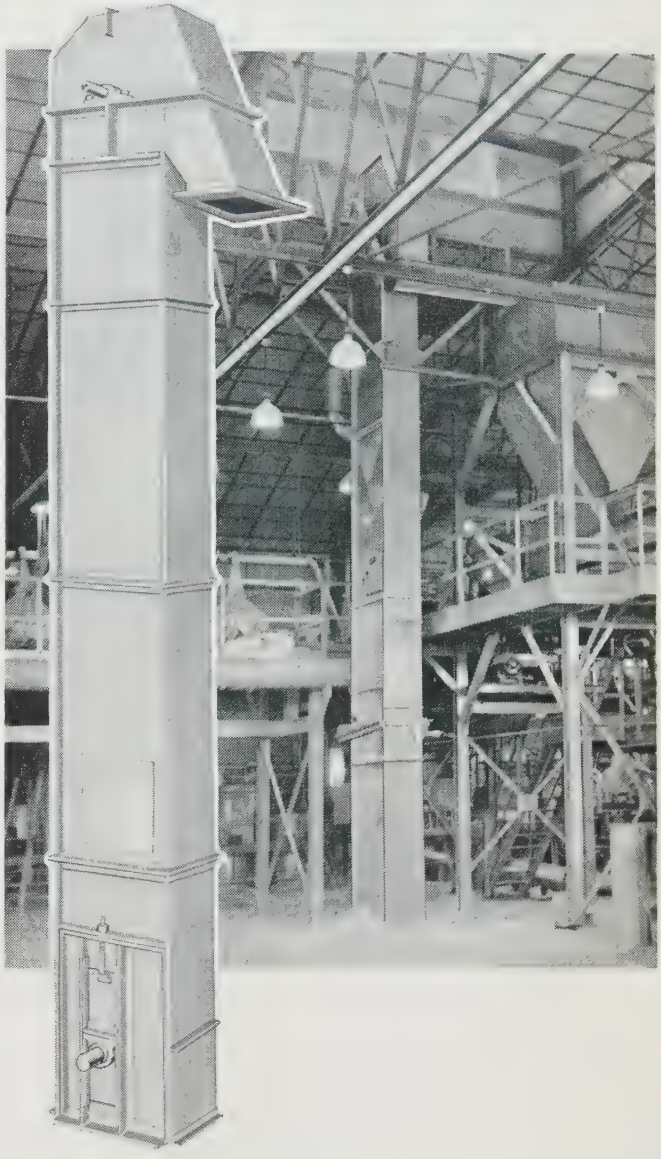

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Myron G. Andrews, formerly of Fibreboard Products, Inc., is now Technical Director of Menasha Pulp and Paper Division, North Bend, Ore.

J. Ronald Atwater is now Vice-President, P. H. Glatfelter Co., Spring Grove, Pa.

Russell C. Barbour, Consultant, has transferred his office from New Rochelle, N. Y., to Upland, Calif.

Howard Baumgarten, formerly of Crown Zellerbach Corp., is now with Arthur D. Little, Inc., Cambridge, Mass.

Henry W. Bennett, formerly of Kimberly-Clark Corp., is now Research Supervisor for Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

Robert B. Birkett, formerly of the Brown Co., is now a Chemist for Fort Orange Paper Co., Castleton-on-Hudson, N. Y.

R. Mundon Bishop, formerly of Dryden Paper Co., is now Assistant Manager of Ryegate Paper Co., East Ryegate, Vt.

Wentworth Brown, formerly of W. R. Grace & Co., is now with International Paper Co., New York, N. Y.

Carl-Olov Carlsson, formerly of Karlstads Mekaniska Verkstad, is now with Tata-Johnson Private, Ltd., Bombay, India.

Frank Caskey, formerly of Morden Machine Co., is now a sales representative for Dearborn Chemical Co., Portland, Ore.

Thomas C. Catlin, formerly of Gilbert Paper Co., is now Mill Manager of Riverside Paper Corp., Appleton, Wis.

Noel N. Coe, formerly of Dorr-Oliver, Inc., is now with Olin-Mathieson Chemical Corp., New Haven, Conn.

Ellsworth J. Cook, formerly of Kelco Co., is now with American Cyanamid Co., Charlotte, N. C.

Elmo Cooley, formerly of Gaylord Container Division, is now Quality Control Technician for Purex Corp., Ltd., St. Louis, Mo.

Richard H. Cordingly is now Assistant Technical Director for paperboard operations of Weyerhaeuser Co., Longview, Wash.

Richard H. Cornell, formerly a Student at The Institute of Paper Chemistry, is now a Group Leader, pioneering research for Riegel Paper Corp., Milford, N. J.

Antonio Corona S., formerly of Papelera Chabacano S. A., is now with Celfimex S. A., Mexico, D. F.

Ernest C. Cowell, formerly of Allied Paper Corp., is now a Sales Representative for Penick & Ford, Ltd., New York, N. Y.

Donald W. Davis, formerly of Milprint, Inc., is now a Chemical Consultant at 7038 N. Beach Drive, Milwaukee, Wis.

Bayard Des Camp, formerly of Rayonier, Inc., is now Kraft Pulp Mill Superintendent for Packaging Corp. of America, Filter City, Mich.

Robert R. Digby, formerly of Roy C. Clark, Inc., is now Manager of Engineering Services for Loftus Engineering Corp., Pittsburgh, Pa.

Peter J. Eberth, formerly of Fabrica Nacional de Papel Tissue, Ltd., Santiago, Chile, is now an Engineer for the Moore & White Co., Philadelphia, Pa.

Bruce W. Ellis is now Vice-President of Buffalo Pumps Division, Buffalo Forge Co., N. Tonawanda, N. Y.

Melvin A. Freytag, formerly of Seabright Oswego Falls Corp., is now a Field Service Representative for Draper Bros. Co., Canton, Mass.

Gunnar A. Gavelin, formerly of the Swedish Forest Products Research Institute, is now Chief Engineer for the Central Laboratory of the Swedish Paper and Groundwood Mills, Stockholm, Sweden.

Louis Georgevits is now Manager of Technical Sales for the Thermoplastic Division of the Borden Co., Bainbridge, N. Y.

Rovert C. Gilardi of the Air Reduction Chemical & Carbide Co. has been transferred from Chicago, Ill., to City of Industry, Calif., as District Manager.

Robert L. Gilmont, formerly of Olin-Mathieson Chemical

Corp., is now Technical Director of Calcasieu Paper Co., Elizabeth, La.

Philippe Ginsburger, formerly of S. A. Cenpa, is now with Cartonneries de la Rochette, Grenoble, France.

Thomas J. Hart is now Supervisor of Polyethylene Coating for the Champion Paper & Fibre Co., Waynsville, N. C.

Edgar W. Heelas, President of National Fiber & Cushioning Corp., has transferred his office from Rockingham, N. C., to San Dimas, Calif.

Paul W. Horeyseck of Continental Can Co. has been transferred from Uncasville, Conn., to Chicago, Ill.

Wm. P. Hunnewell of Continental Can Co. has been transferred from Uncasville, Conn., to Chicago, Ill.

J. Kjeller Johansen, formerly of A/S Mesna Tresliperi og Kartonfabrik, is now with Sande Paper Mills A/S, Sande, Norway.

Melvin L. Johnson, formerly of Container Corp. of America, is now with Carton y Papel de Mexico S. A., Tlalnepantla, Edo, Mexico.

Helmer E. Johnsson, formerly with Skanska Attikfabriken A/B, is now with A/B Tilafabriken, Trelleborg, Sweden.

James E. Kearney, formerly of Ebasco Services, Inc., is now Assistant General Manager of the Integrated Products Division of Beloit Iron Works, Beloit, Wis.

Duane R. Keck, formerly of Champion Paper & Fibre Co., is now with Bowaters Board Co., Catawba, S. C.

Walter B. Kinne, formerly of Whitman Laboratories, Inc., is now Chief Chemist for American Plastics Corp., Division of Heyden Chemical Co., Bainbridge, N. Y.

Wilbur L. Kite, formerly of Lee Paper Co., is now a Staff Scientist in the Research Department of the Mead Corp., Chillicothe, Ohio.

John E. Knecht is now Manager of Engineering Services for Bathurst Containers, Ltd., Montreal, Que.

Hans Lundgren of Continental Can Co. has been transferred from Uncasville, Conn., to Chicago, Ill.

Frederick R. Lynch of Continental Can Co. has been transferred from Tonawanda, N. Y., to Haverhill, Mass., as Project Engineer.

Robert F. Lynch is now Production Manager of St. Regis Paper Co., Tocoma, Wash.

Cecil E. McDonald is now Vice-President of Riordon Sales Corp., Ltd., New York, N. Y.

Martti Maki, formerly with Cartiere Antonio Sterzi, is now an Engineer with Yhtyneet Paperitehtaat O/T, Simpele, Finland.

Sol H. Markowtiz, formerly of Berkshire Color & Chemical Corp., is now with Pap-Tex Color & Chemical Co., Inc., North Wilbraham, Mass.

John A. McDermott is now Vice-President in Charge of Pulp and Paper Manufacture for St. Regis Paper Co., Jacksonville, Fla.

William F. McKee, formerly of Abitibi Power & Paper Co., is now General Superintendent of Nova Scotia Pulp, Ltd., Point Tupper, N. S., Canada.

Thomas. S. Morse of Hercules Powder Co. has been transferred from Wilmington, Del., to Montreal Que., Canada, as Sales Manager.

Jack Mulyk, formerly of American Boxboard Co., is now Operating Superintendent for Celgar, Ltd., Kraft, B. C., Canada.

Elbert H. Neese, Jr., is now President and General Manager of Beloit Eastern Corp., Downingtown, Pa.

John R. Nelson is now Production Manager for Papering Chemicals for Nalco Chemical Corp., Chicago, Ill.

Willy R. Noiset of Continental Can Co. has been transferred from Uncasville, Conn., to Chicago, Ill., as a chemist.

Richard V. Osborn, Director of Product Planning of Great Northern Paper Co., has been transferred from E. Millinocket, Me., to New York, N. Y.

Edward G. Paxton, Jr., Research Engineer for Continental

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Can Co., has been transferred from Uncasville, Conn., to Chicago, Ill.

Sam H. Popovich, formerly of S. H. & F. Jordon, Jr., Mfg. Co., is now Technical Director of Westfield River Paper Co., Inc., Russell, Mass.

Arthur W. Plummer, formerly of Hudson Pulp & Paper Co., is now Director of Industrial Engineering for S. D. Warren Co., Cumberland Mills, Me.

Stanely Popkins, formerly of Gibralter Corrugated Paper Co., is now with Elk Paper Co., Childs, Md.

S. Kepple Pratt of St. Regis Paper Co. has been transferred from Tacoma, Wash., to Jacksonville, Fla., as Manager of Kraft Pulp and Paper Manufacture.

Walter H. Randall is now Vice-Preisdent for Engineering and Research for Keyes Fibre Co., Waterville, Me.

Kenneth E. Rauenbuhler, formerly of the Mead Corp. (Gibralter), is now an engineer with Federal Paperboard Co. Bogota, N. J.

Hans M. Riessner, formerly of H. A. Simons, Ltd., is now a Design Engineer for A/B Morrums, Bruk, Morrum Sweden.

Georg H. Saaf-Norden, formerly of the Austrian Pulp and Paper Assocation, is now Administrative and Technical Adviser of Frantschach Pulp and Paper Mill, Vienna, Austria.

Harry F. Schenk, formerly of Magnus Metal Corp., is now with Harry F. Schenk Associates, Leominster, Mass.

Anna May Schenk, formerly of Continental Can Co., is now Associated Editor of *Package Engineering,* Chicago, Ill.

Charles Schenker is now Pulp Mill Superintendent for the Buckeye Cellulose Corp., Memphis, Tenn.

George H. Simpson, formerly of Hinde & Dauch, Ltd., is now with St. Lawrence Corp., Ltd., Montreal, Que., Canada.

Mauri A. Soininen, formerly of Haarlan Selluloosayhtio, is now a department head for Rauma-Repola O/Y, Valko, Finland.

William R. Streed, formerly of Industrial Designing & Development Co., is now with Machine Products Co., Inc., Gadsen, Ala.

Clinton V. Tasker, formerly of American Viscose Co., is now Director of Technical Research and Development, Packaging Corp. of America, Grand Rapids, Mich.

Joseph F. Thieriault, Chemist of Continental Can Co., has been transferred from Uncasville, Conn., to Chicago, Ill.

William C. Thibodeau, formerly of Continental Can Co., is now Chemical Engineer for Gulf States Paper Corp., Demopolis, Ala.

Leslie E. Towle of Spaulding Fibre Co. has been transferred from N. Rochester, N. H., to Tonawanda, N. Y., as Assistant Manager of the Fibre Department.

Russell E. Vannatta, formerly of the Exallo Paper Products Co., is now Plant Manager of the Mead Corp., Cincinnati, Ohio.

H. Ward Verseput, formerly of Continental Can Co., is now in the Research and Development Laboratory of Riegel Paper Corp., Milford, N. J.

John Verwayen, formerly of the Mead Corp., is now with Federal Paper Board Co., Inc., New Haven, Conn.

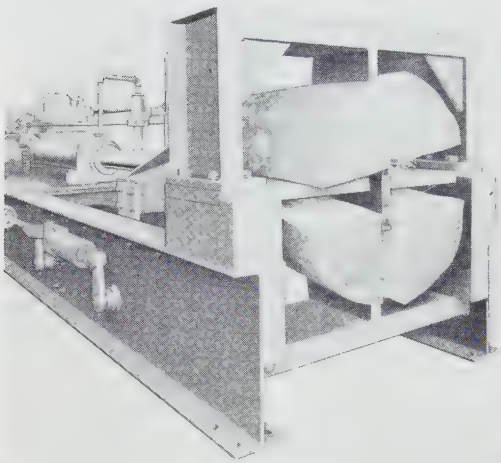
Peder Waern-Bugge, formerly of the Royal Institute of Technology, is now Chemist for A/B Statens Skogsindustrier, Lovholmens Bruk, Pitea, Sweden.

David Wetherhorn, formerly of Continental Can Co., is now an engineer with W. C. Davis Associates, Savannah, Ga.

Lloyd A. Whittaker of Thomson National Press Co., Inc. has been transferred from Franklin, Mass., to Los Angeles, Calif., as Western Manager.

Roger N. Wiewel, formerly of Weyerhaeuser Co., is now Pulp Sales District Manager of Stora Kopparberg Corp., New York, N. Y.

Richard A. Yanka, formerly of Fitchburg Paper Co., is now a Paper Technologist for the Hubinger Co., Keobuk, Iowa.



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INDUSTRY NOTES

North American

Statistics

*Paper and Paperboard Production**

Paper production in January, 1961, averaged 87.8% of capacity, compared to 96.5% in January, 1960. However, the decline in tonnage production of paper in January, 1961, was not as great as these ratios might indicate, because of the increase in paper capacity during 1960. Paperboard production in January, 1961, averaged 88% of capacity, compared to 92% a year earlier. Here, too, the lower operating ratios reflected, in part, increases in paperboard capacity installed during 1960. On balance, these figures indicated that total paper and paperboard production in January, 1961, averaged out about 5% below the year-earlier level.

*Pulpwood**

Total receipts of pulpwood for the year of 1960 were 40,963,000 cords, an increase of 2,902,000 cords over receipts for the comparable period last year. Domestic receipts were 2,835,000 cords above the year earlier total, and imports increased 67,000 cords. All of the regions showed increases ranging from 1% in South Central to 13% in the Western region.

Pulpwood consumption for the year 1960 was 40,315,000 cords, an increase of 1,624,000 cords over the same period of 1959. All of the regions showed increases ranging from 0.3% in South Central to 8% in the Western region.

Inventories of pulpwood at the end of December were 5,924,000 cords, an increase of 33,000 cords above November, 1960, and 751,000 cords above December, 1959. The Northeastern and South Central regions showed decreases ranging from 2 to 9%, respectively. All the other regions showed increases ranging from 8% in North Central to 43% in the Western region.

*Wood Pulp**

Production of wood pulp for January–December, 1960, was 25,064,000 tons, an increase of 905,000 tons above the comparable 1959 total.

Wood pulp consumption in the manufacture of paper and board for January–December, 1960, was 25,528,000 tons, an increase of 470,000 tons above consumption for the same period last year.

Imports of wood pulp for January–December, 1960, were 2,384,422 tons, 2% below imports for last year. Imports from Canada for January–December, 1960, were 2,039,473 tons, 3% above the comparable period of 1959. Overseas imports for January–December, 1960, were 344,417 tons as compared to 453,625 tons for the same period last year.

Exports of wood pulp for January–December, 1960, were 1,141,797 tons as against 652,524 tons exported during the same period last year.

Inventories of wood pulp at paper and board mills at the end of December were 533,859 tons, 11,957 tons below inventories at the end of November and 840 tons above inventories at the end of December, 1959.

*Wastepaper and Other Fibrous Materials**

December wastepaper receipts were 765,000 tons; for the full year of 1960 they totaled 8,986,000 tons, a decrease of 328,000 tons below receipts for last year.

Wastepaper consumption for December was 752,000 tons; the January–December total was 9,012,000 tons, a decrease of 149,000 tons from consumption for the same period last year.

Inventories at the end of December were 561,000 tons, 13,000 tons above November and a decrease of 27,000 tons below inventories at the end of December, 1959.

Consumption of total fibrous materials for December was 822,000 tons; the January–December total was 9,951,000 tons, 234,000 tons below consumption for the comparable period last year.

Inventories of total fibrous materials at the end of December were 1,033,000 tons, 79,000 tons above November and 34,000 tons below inventories at the end of December 1959.

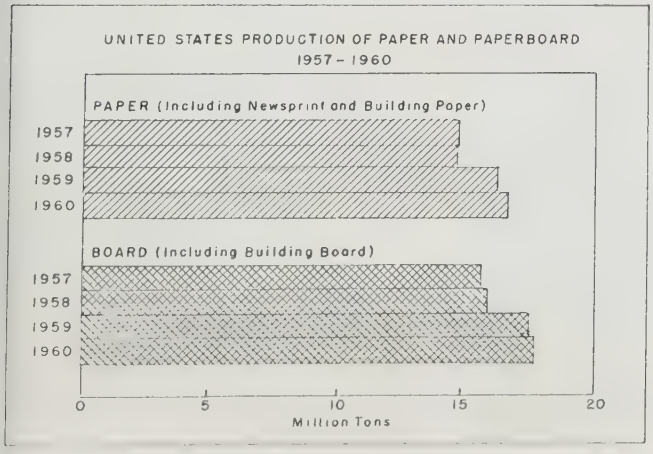
Container and Packaging

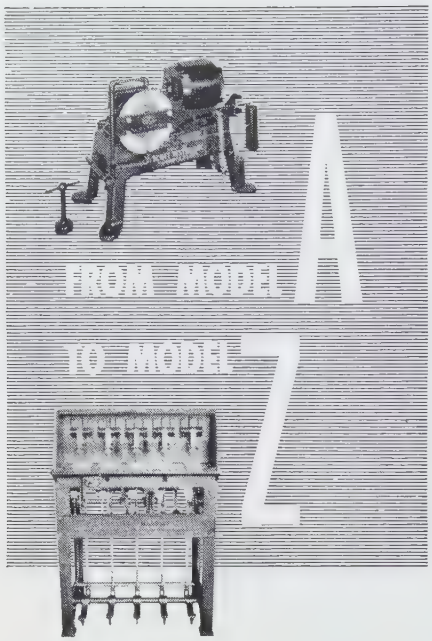
Container activity for 1960 will undoubtedly fall short of the record 1959 volume, but will exceed the volume of any other previous year. A composite weighted average of expected industry performance shows that 1960 business will be 1 to 2% below the 1959 total, assuming that fourth-quarter volume exceeds the 1959 level by about 2%; preliminary fourth-quarter figures indicate this level of operation. Of the container manufacturers interviewed in the regular quarterly survey, 45% expect 1960 business to decline from 1959 by anywhere from 1 to more than 25%; the majority estimating 5–10%. Gains were foreseen by 40% of the panel, less than 5% being the consensus.

At the end of 1960, container management is cautiously optimistic over the business propsects for the new year. For example, slight or conservative gains over 1960 are visualized by the following industries: Glass container, metal can, aluminum foil packaging, converted flexible packaging products, paper bag, folding paper boxes, paper shipping sacks, and corrugated shipping containers. Steel shipping container business is expected to approach the 1960 volume. Because of the high rate-use factor, the 1961 trend in containers will undoubtedly follow closely output and sales of nondurable goods, particularly food. Expansion in this sector of the economy will undoubtedly benefit the overall packaging field.

—*Container and Packaging* (U. S. Dept. of Commerce) 13, No. 4 (Winter 1960 61).

* American Paper and Pulp Association, *Monthly Statistical Summary*, 39, No. 3 (March 1961).





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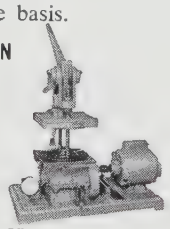

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SCOTT TESTERS

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Canadian Operational Research Society

The Third Annual Conference of the Canadian Operational Research Society will be held in Ottawa on May 4 and 5, 1961, with morning and afternoon conference sessions on both days, held in the Auditorium of the Chemistry Building of the University of Ottawa. The conference dinner will be held on the evening of May 4 at the Chateau Laurier, and Dr. Philip M. Morse will be the guest speaker.

The fee for the conference is $12 for CORS members and $15.00 for nonmembers. Inquiries about the conference may be directed to David W. McLimont, Chairman of the Program Committee, The E. B. Eddy Co., Hull, Que.

Overseas

Australia

A new comprehensive report of Australia's paper, chemical, textile industries has been issued. Prepared by the Commonwealth's Department of Trade, the 28-page study showed the following upward industry trends: paperboard production and consumption up 25% since 1957, caustic soda production doubled in the past 10 years, 20% rise in wool yarn output and sales since 1959.

United States firms already operating in Australia include: St. Regis Paper, Lily-Tulip Cups, Gibson Greeting Cards, American Cyanamid, Monsanto, Stauffer Chemical, Union Carbide, Bigelow-Sanford, Jantzen, Owens-Corning Fiberglas, B.V.D., Bates Fabrics, Cluett-Peabody.

Total United States investment in Australia reached the $1 billion mark this year, and more than 1000 American firms are associated with Australian companies.

Industries specifically covered in the study include pulp, paper, paperboard; alkalis, chemical fertilizers, petroleum refining; wool tops, wool, cotton, and man-made fiber yarns. In each category, charts and statistical indices pinpoint industry characteristics including production-market costs, materials, investment, overseas trade.

Copies of the report, "Survey of Manufacturing Activity in Australia," are available without cost by writing the New South Wales Government Office, Dept. P, 680 Fifth Ave., New York 19, N. Y.

Paper Manufacturers and Converters

Appleton Coated Paper Co.

A new, modern finishing building which houses trimming and packaging operations has recently been completed by the Appleton Coated Paper Co., Appleton, Wis. The new facility is part of a continuous expansion program designed to keep pace with the rapidly increasing markets for the company's coated paper products.

Crown Zellerbach Corp.

Parlin Award

Harold L. Zellerbach, chairman of the executive committee of Crown Zellerbach Corp. and chairman of the board of Zellerbach Paper Co., has been selected as this year's recipient of the American Marketing Association's highest honor—the Charles Coolidge Parlin Memorial Award. The Parlin Award, established in 1945, is presented annually for outstanding achievement in the field of marketing and marketing research.

Staff

A. G. Curtis has been appointed manager of Crown Zellerbach's southern timber operations in a general realignment of responsibilities for forest management and pulpwood procurement in the South, it was announced today by O. D. Hallin, vice-president. In his new position, Mr. Curtis will be in charge of both functions. Mr. Curtis has been serving as manager of pulpwood procurement for the company's manufacturing operations in Louisiana since April 1, 1938.

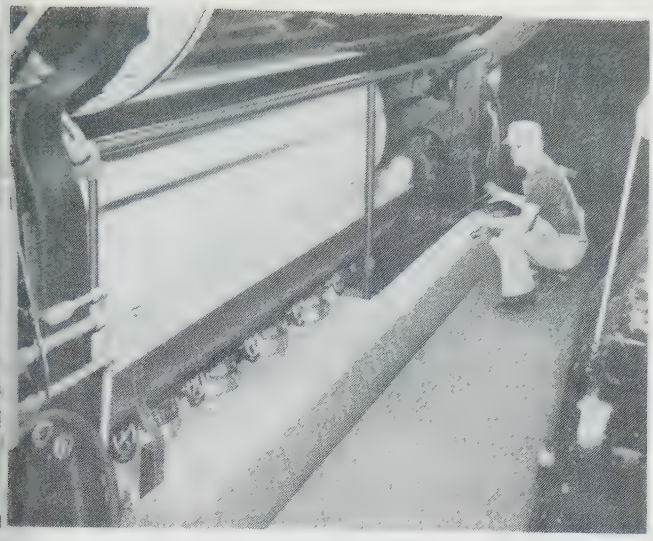
P. H. Glatfelter Co.

The Board of Directors of the P. H. Glatfelter Co. announced today the election of J. R. Atwater as vice-president, Administration. Prior to Mr. Atwater's new appointment he served as assistant to the president. He joined the Glatfelter Co. in 1957 and has been associated with the pulp and paper industry for many years.

Great Northern Paper Co.

The directors of Great Northern Paper Company have elected Peter Standish Paine, senior vice-president. M. C. McDonald, the company's president, reaches the age of 65 in 1961 and has indicated his desire to retire at the end of the year. It is contemplated that when he does so, Mr. Paine will be elected to the office of president.

John T. Maines, manager of woodlands, has been elected vice-president and manager of woodlands of the company. Mr. McDonald also announced the promotion of David F. Pollard of Millinocket to the position of manager of manufacture.



Machine tender regulates air supply to one section of Ross high-velocity drier at New York and Penn no. 8 machine in Lock Haven, Pa.

Great Northern Paper Co., at its annual meeting held March 15, 1961, elected Hoyt Ammidon, Robert A. Haak, and J. H. Heuer directors of the company.

New York & Pennsylvania Co.

High Velocity Drier

When New York and Penn decided to increase the production of their no. 8 machine, they had the choice of adding three drum driers to the afterdrier section, or of installing a high-velocity air drier beneath an existing drum. Since they were short of floor space, the high-velocity drier was selected. They found the high-velocity drier had other advantages too—it could be installed without moving rewinders and other equipment, and it cost less.

Once the new drier was installed, NYPen increased no. 8 machine bulky book paper output in the neighborhood of 25%. Speeds rose from 400–425 to 500–550 f.p.m. At this increased rate of production, additional earnings easily paid for the drier in less than a year.

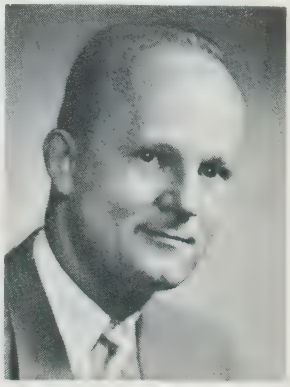
The drier selected was the DL type supplied by the J. O. Ross Engineering Div. of the Midland-Ross Corp., New York, N. Y. This drier is essentially a sheet-metal chamber that fits under (or over) and partially around a drum drier. The drier discharges air against the traveling web through slots at velocities up to 15,000 c.f.m. and at temperatures up to 315°F. The machine tender controls air velocities by adjusting dampers in six ducts which connect the main air supply header with the drier. The drier is divided by vertical partitions into six separate compartments, each serviced by one of the six supply ducts. Different velocities can be maintained at different web locations if moisture content varies across the sheet. The tender controls temperature by means of an indicating temperature-controller that regulates the flow of steam through coils over which the high-velocity air is circulated.

The six independent drier sections are each partitioned in two by horizontal dividers. Incoming air is ducted directly to the compartments next to the web and discharges through the slots in the duct. These slots run parallel with the width of the web. Return air is drawn into inlets located between the air-supply slots and is piped to the outer compartments from which it enters a second header and is returned to the Ross heater. The heater brings it back to operating temperature and it is recirculated to the drier.

The machine tender can drop the drier out of position for threading by operating a pneumatic cylinder that hinges the unit downward several inches from the drum. The air heater and circulating fan are in the basement under the afterdrier, close to the high-velocity drier. The high-velocity drier is installed beneath the first drum drier of the afterdrier section.

Northeastern Paper Sales

J. D. G. (Don) Thomson has been appointed manager of pulp sales in the United States and Canada. Northeastern Paper Sales, Inc., is the exclusive sales representative for Gaspesia Sulphite Co., Ltd. and Anglo-Newfoundland Development Co., Ltd., in the United States and Canada.



J. D. G. Thomson, Northeastern Paper Sales, Inc.

St. Regis Paper Co.

Graduate Fellowships

St. Regis Paper Co. announces that in recognition of the importance of scientific forestry methods it again offers two graduate fellowships in forestry in addition to five under-

Calender • Napkin • Schreiner • Embossing • Steel • Wool Felt • Cotton and Wool
Paper Filled • Combination • Porcupine • Fiber • Stainless Steel • Supercalender
Husk • Special Purpose • Brass • Cotton Filled • Roll Grinding • Roll Repairs
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Importers of the finest laboratory instruments for the pulp and paper industry

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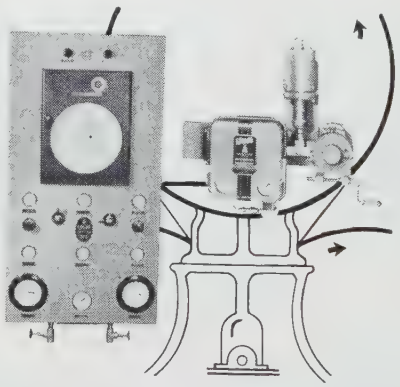

It's the most simple, trouble-free system ever built . . . yet it maintains any moisture content desired in any weight of paper

The Stickle Pres-ten-trol uses the time-tested, mill-proven principle of sheet expansion and contraction to regulate steam flow to the dryers . . . for any weight of paper from .0003 to the heaviest board. It provides instant regulation with minimum fluctuation . . . records moisture variation, steam pressure in dryers, time and duration of wet end breaks . . . holds steam pressure desired when paper is off the machine. On a recent 24-hour test, moisture content varied only 3/10 of 1%. Yet, no other system costs so little to buy, install, operate and maintain, because no other is so simple, so trouble-free. Write for Bulletin 460-C.

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Cuts the cost of steam

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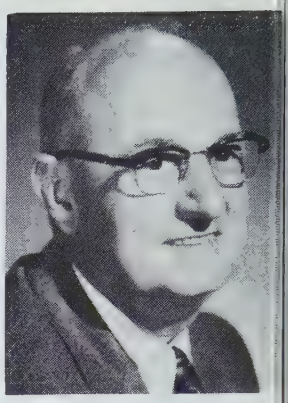


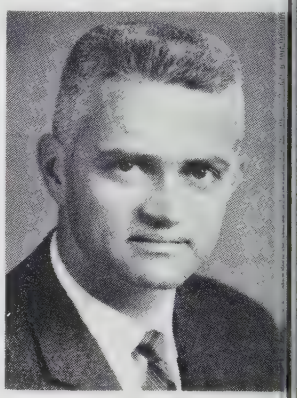
J. M. Lamb,
St. Regis Paper Co.

graduate scholarships in forestry. The fellowships a values at $1000 each and are given for one year.

Winners of the two St. Regis Fellowships in Forestry th year are Charles H. A. Little of the University of Ne Brunswick School of Forestry and James H. Gottsacker the New York State University College of Forestry Syracuse University.

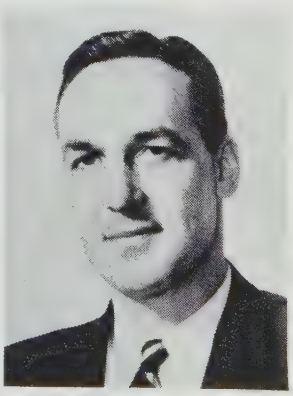
Staff

St. Regis Paper Co. announced that Gordon Inskeep ha been appointed manager of program planning and personn for the Technical Division. In this position, he will b responsible for the preparation of technical programs i the central departments of Research and Development and Technical Services and Control, and for the administration of corporate personnel policies within the Technical Division, including professional technical personnel recruitment and development. Mr. Inskeep will report to T. A. Hewson, assistant vice-president, technology.



G. C. Inskeep,
St. Regis Paper Co.

St. Regis is constructing a new technical center at Clarkstown, N. Y. The center, which is scheduled for completion in the latter part of this year, will serve as headquarters for the St. Regis research and development departmen technical services and control, and technical planning d partments. Mr. Inskeep, who makes his headquarters at th New York Office, will be responsible for recruiting profes sional personnel for the new Center.



W. J. Davis,
St. Regis Paper Co.

S. K. Pratt,
St. Regis Paper Co.

St. Regis Paper Co. has also announced that William R. Haselton, now vice-president and general manager of the Rhinelander Paper Co. Div., will succeed Jack M. Lamb as general manager, Tacoma, Washington area operations, when Mr. Lamb retires on June 30 of this year. Mr. Lamb will continue as a consultant to the company.

Willmer J. Davis, vice-president in charge of sales at Rhinelander, will succeed Dr. Haselton as vice-president and general manager there. He, in turn, will be succeeded as vice-president by Charles C. Johnson, who is now sales manager at Rhinelander.

S. Kepple Pratt, resident manager of the Tacoma pulp and paper mill, will become manager of kraft pulp and paper manufacturing, reporting to John A. McDermott, vice-president in charge of pulp and paper manufacture. Mr. Pratt will make his headquarters at Jacksonville, Fla.

Robert F. Lynch, now manufacturing superintendent at Tacoma, will become production manager there.

Sorg Paper Co.

The Sorg Paper Co. of Middletown, Ohio, following its established practice of keeping its papermaking in the fore-front of progressive mills, has again made papermaking history.

On Jan. 19, 1961, the first multiunit Rotoformer wet end went into production in the Sorg mill. This three-unit arrangement replaced a five-vat wet end on Sorg's no. 2 paper machine on which tag stock, cover stock, telephone book cover and a variety of specialty sheets of similar character are produced.

There are more than 20 of The Sandy Hill Iron and Brass Works' Rotoformers operating in the trade as single units or in combination with previously installed forming elements, but this installation is the first multiformer wet end where the whole thickness is achieved by pickup from successive Rotoformers.

The century-old history of Sorg is studded with many other "firsts." Among the notable achievements in this respect were: The first manila paper made west of the Allegheny Mountains; the first successful waxing sheet—developed for the famous "Inner Seal" used by the National Biscuit Co.; the first successful textile spool paper made in this country (Sorg is still the chief supplier to the textile industry of this paper which was originally made in France); the first suitable film casting paper, which is used as a carrier for liquid plastics; the first wet-strength facial tissue; the first successful offset printing paper; one of the first practical latex-impregnated printing papers; and Sorg is one of the first American paper mills to produce a quality-base paper for playing cards.

Sorg's interest in the Rotoformer developed during their search for new and better ways of forming cylinder papers. Various older conventional methods and more recent innovations were thoroughly studied and it was decided that the Rotoformer offered advantages which warranted further investigation. About a year ago a single Rotoformer was installed to replace one vat on the no. 2 machine.

This Rotoformer unit was set up at the end of the cylinder machine without a pickup felt. With this setup the sheet formed could be stripped from the cylinder of the Rotoformer and passed over an open draw. It was then placed in the nip of the last cylinder couch, to be laminated with the product of the remaining four cylinders.

Such good results were indicated in the possible production of a variety of desirable sheets that Sorg's staff was convinced that three Rotoformers could replace the five conventional cylinder vats. After considerable study and discussion among Sorg's operating and engineering personnel and Sandy Hill, the arrangement of the multiunit installation was decided upon.

The use of three Rotoformers to take the place of five vats effected a saving in space which could be used for additional drying or the spreading of the press section.

Sorg elected to give more room to the press section and a Patton press section was installed at the same time as the Rotoformers, still leaving space for additional driers or presses as determined desirable.

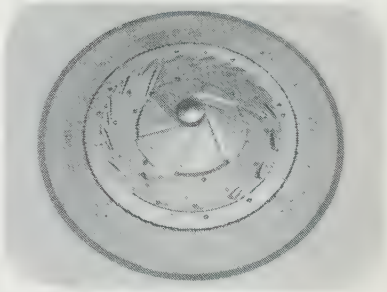
Inasmuch as the wetness of the sheet at the point of pickup can be controlled on the Rotoformer the installation was designed so that the sheets are picked up on the first two units and then sufficiently dried on no. 3 Rotoformer to permit the sheet to be passed over an open draw to the press felt.

This dryness of delivery from the last unit, which permits the sheet to leave the pickup felt ahead of the first press, is unique in multicylinder operation.

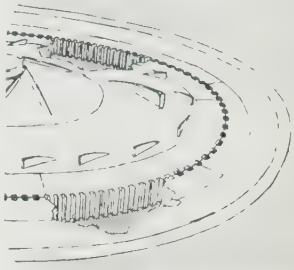
The ply bond has proved to be very good and there is virtually no drop-off.

The three Rotoformers are arranged so that the paper travel is always

NOBLE & WOOD'S
EXTRACTA PULPER
Lowers Costs
Increases Production
Improves Quality



The EXTRACTA'S ROTOR is the key to its superior performance*



*Noble & Wood engineers have incorporated, for the first time, the principle of extracting through rotating and stationary elements. This feature adds fiber selection plus primary refining to conventional pulping in one single, compact, rugged unit.

For full information on what looks like the hottest news in the paper industry, write or phone us at once. (We have an interesting color film on the EXTRACTA PULPER at work that you'd like to see.)

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- Jet-Type Sulphur Burners
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- Spray-Type SO_2 Gas Cooling Systems
- Recovery Towers
- Sulphite Acid Systems
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- Neutral Sulphite Semi-Chemical Liquor Plants
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- Black Liquor Oxidation Systems for Sulphate Pulp Mills

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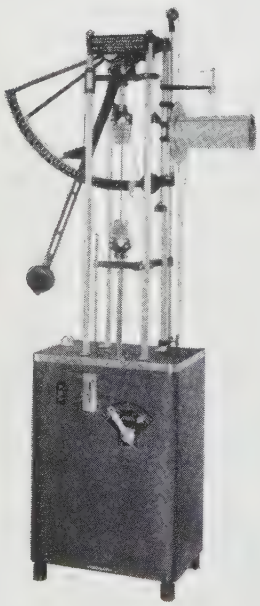

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T–456	T–481
T–457	T–644

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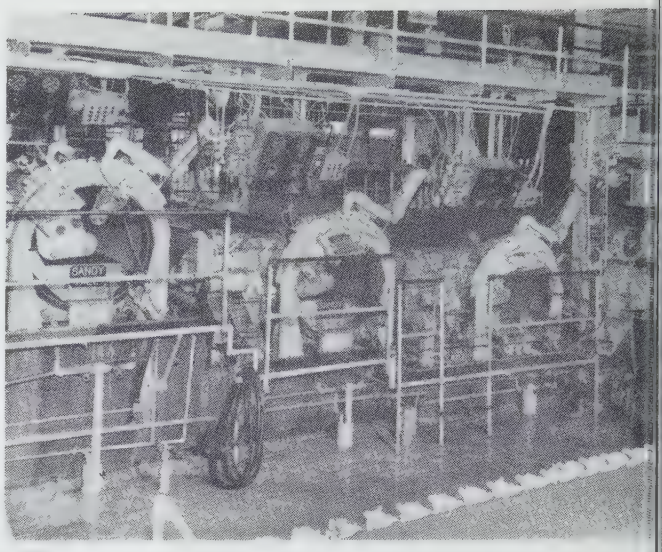


Overall view of Sorgs' Rotoformer installation

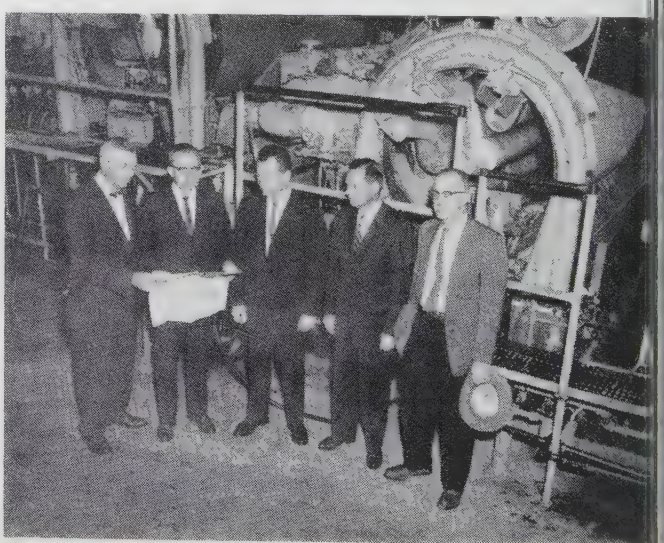
toward the dry end. The first sheet is picked up farthest from the driers and progresses in the same direction through the press section. The control of sheet dryness permits the operation of a single Rotoformer without any pickup felt and makes it possible for Sorg to produce a sheet on either one, two, or three Rotoformers.

Eliminating the need of the pickup felt going through the presses has produced several advantages for Sorg. They are able to use a much shorter pickup felt. Felt cleaning problems are reduced because fibers are not pressed into the felt weave, as is the case when the felt goes through the primary presses in the conventional cylinder setup.

As a result of the drier sheet going into the press section and the greater efficiency of the new press section Sorg engineers expect a substantial steam economy in the drier section.

Sorg has found other improvements over conventional operation. They find that lumpy formation is avoided due to the fact that after the sheet is formed it is not drawn through a pond or slurry and so the formation, once accomplished, is not disturbed. After the sheet is formed, vacuum prevents any slip back of the stock.

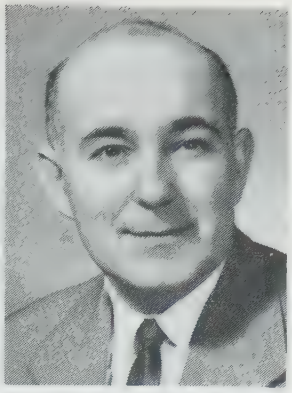
Wetness at the point of pickup underneath the couch roll is



Dorsey R. Morrison, superintendent of mill no. 1; Donald J. Goodman, general superintendent of papermaking; D. M. Yost, research and technical director; Carl H. Eisenmenger, vice-president of operations and I. D. Sisson, chief engineer

controlled by a separate vacuum box which can be located as suits the papermaking requirements. The position of the couch roll can also be changed.

Piping for the whole installation, together with mix boxes and seal boxes and the like, was engineered by Sorg, and built by Brown-Singer. All piping and mix boxes are stainless steel and seal boxes and white water tank are tile construction.



S. H. Popovich, Westfield River Paper Co.

Centrifugal pumps are by Goulds and Allis Chalmers.

The fan pump valves are DeZurik remote control.

The vacuum pumps are by Nash.

The suction press roll was supplied by Manchester Machine.

Vacuum controls are by Mason-Neilan.

Each Rotoformer is driven independently by a Dynamatic drive as supplied by the Eaton Manufacturing Co. The relative speed of the three Rotoformers in controlled by adjustments in the eddy-current coupling controls.

Each couch roll is controlled by air loaded cylinders and the adjustments for loading and lifting these are made from Foxboro panels at the tending side of the machine.

The anticipated formation advantages, such as levelness of profile, better formation, more pickup, of the Rotoformer were realized.

It is Sandy Hill's belief that experience at Sorg would indicate that it may be possible to eliminate such things as suction drum presses and reduce the number of primary presses in a board setup.

Results to date lead Sorg to be pleased with their decision and optimistic that further benefits will be realized in the improvement of present grades and the development of new Sorg products.

The results of the experimental work on the single Rotoformer installation, which were such as to encourage the Sorg management to decide on the multiunit installation, were the joint effort of D. M. Yost, research and technical director; Donald J. Goodman, general superintendent of papermaking; and Dorsey R. Morrison, superintendent of mill no. 1. On Mr. Morrison's shoulders fell much of the responsibility for putting the new installation into production and solving any unforeseen problems that might arise in so revolutionary a departure from conventional papermaking methods.

I. D. Sisson, chief engineer, working with his own crew and the engineering staffs of the various equipment suppliers, was responsible for the general layout.

Carl H. Eisenmenger, as vice-president of operations, shoulders the final responsibility for the success or failure of the entire project. It is to the courage of such men as Mr. Eisenmenger and Donald G. Driscoll, president of The Sorg Paper Co., that the company owes its reputation for being a progressive and forward moving organization.

Westfield River Paper Co.

Westfield River Paper Co., Inc., has named Sam H. Popovich as technical director, it has been announced by Paul F. Moore, president. Mr. Popovich will be located at the principal office of the company at Russell, Mass., and will be responsible for all technical operations at their glassine and greaseproof mills at Russell and Lee, Mass., and at West Conshohocken, Pa.

Educational Institutions

Institute of Paper Chemistry

Textbook Dedicated to Lewis

The textbook for a specially designed chemistry course for high school students has been dedicated to Harry F. Lewis, vice-president of The Institute of Paper Chemistry. The course is known as the Chemical Bond Approach Project. Sponsored by the Chemical Education Division of the American Chemical Society, the course and textbook were prepared with an initial grant from the Crown Zellerbach Foundation and later grants totaling more than $800,000 from the National Science Foundation. Cooperating in creating the course and textbook were prominent university, college, and high school chemistry teachers.

Seventh Chapter of Microscopy Book

Chapter seven of the book "Pulp and Paper Microscopy" has been completed by Irving H. Isenberg, research associate at The Institute of Paper Chemistry, and will soon be sent to the book's subscribers. The reference-text book is published by The Institute of Paper Chemistry and produced in such a

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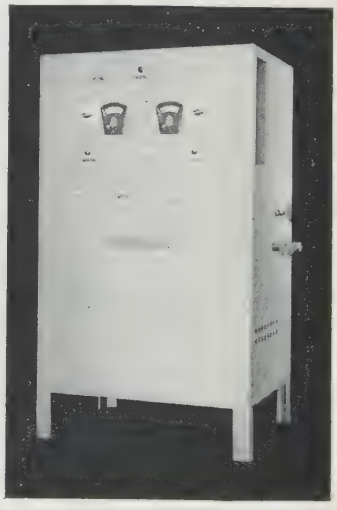
Heat Transfer Systems



These highly versatile units will handle all of your process heating jobs to perfection—big or little!

For ROLLS, APPLICATOR, PANS, MILLS, CALENDERS, SUPPLY TANKS, MIXERS, etc. . . , Production and Laboratory installations alike.

ENGINEERED FEATURES YOU REQUIRE!

- *High temperatures at low pressures—virtually no vapor pressure.*
- *Great uniformity of heat with close temperature controls (to ½ of one % of temperature range) up to 500°F.*
- *Custom units designed to your special needs at higher temperatures.*
- *Multiple temperatures from the same compact system, independently and closely controlled.*
- *Rapid cooling if desired—finned tube heat exchangers installed on specification—controlled manually or automatically.*

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fashion that chapters can be added to the book as they are completed, allowing subscribers to use previously completed chapters. Twelve chapters are planned for the book.

Summer Conference for College Teachers

The Institute of Paper Chemistry, Appleton, Wis., will present a summer conference for college teachers of chemistry and biology, August 14 through 25.

The conference, "An Introduction to Plant Biochemistry," will take 25 selected teachers through 12 days of lecture-discussion sessions in various subject areas, and lecture-demonstrations showing instrumentation and techniques in ten primary research areas of the Institute.

Five prominent guest lecturers will join 11 members of the Institute's staff as faculty for the conference. Director of the conference is Dr. Elwood O. Dillingham, research associate in the biology group at The Institute of Paper Chemistry.

Lecture-discussion sessions will deal with the current status of wood chemistry, biological and biochemical aspects of wood technology, plant physiology, morphogenesis, protein structure, mechanism of enzyme action, protein biosynthesis, and feedback control of metabolic systems.

Lehigh University

Research-minded technical men in the graphic arts industries are urged to broaden their spheres of knowledge through advanced study, it was stated recently by A. C. Zettlemoyer, research director of the National Printing Ink Research Institute and Distinguished Professor of Chemistry at Lehigh University.

High level research is not only needed to raise the graphic "art" to a science, but it can be just as exciting as the more seemingly glamorous jet and space fields. In fact, all sciences require printing for communication and therefore lean on the Graphic Arts for their own progress.

"Gone are the days when progress could be made on old-fashioned string and bailing wire stop-gap methods," said Dr. Zettlemoyer. He went on to cite that electronic computers, high-speed photography, and other scientific advancements are being resorted to more and more to solve basic problems upon which progress in the graphic arts depends. In addition, bigger roles are being played by classical physical chemistry tools, such as measurements of light scattering, heats of wetting, radiotracers, to mention only a few.

A major problem is the inability to attract qualified men to undergo the training period. The logical training ground is in the graduate schools of universities, but despite fellowships and graduate assistantships of reasonable remuneration, these go unfilled due to the lure of initial high salaries paid by industry. Yet the long-term advantages of advanced study cannot be overemphasized.

Prospective candidates interested in pursuing courses of study and research leading to Masters Degrees as well as Doctorates are requested to contact Dr. Zettlemoyer, at NPIRI, Chemistry Dept., Lehigh University, Bethlehem, Pa.

Lowell Technological Institute

Geoffrey Broughton Memorial Scholarships

Geoffrey R. Broughton memorial scholarships of $100 each given by interested companies in the paper industry were presented for the spring semester at Lowell Technological Institute to the junior and senior in paper technology with the highest average for the preceding semester.

Paper Summer Course

A two-week professional advancement summer course in Paper, Its Properties and Uses will be conducted June 12 to 23 in the Department of Paper Technology at Lowell Technological Institute. The program, similar in scope to last year's successful one, is endorsed by the Boston Paper Trade Association and the New England Paper Merchants Association.

Left to right are Dean of Students, Richard W. Ivers, Thomas F. Kelly, '62, Norman T. Veillette, '61, both of Lowell, and Dr. Dominick A. Sama, head of the department of chemical engineering and paper technology

The course is designed to present in a practical way information about papermaking and the properties of paper in order to determine the value and suitability of paper and paperboard for various end uses. It will be conducted by Prof. Edward M. Engel and Prof. Charles J. Higgins of the LTI faculty, and guest lecturers from industry also will participate.

Enrollment is limited, and applications will be accepted as received. Total cost of the course, including tuition, lodging, meals, books, and transportation on field trips, is $200. Letters of application with a deposit of $10 should be sent before May 10 to Paper Summer Course, Lowell Technological Institute, Lowell Mass., and further information may be obtained by writing there.

University of Maine

Brown Company Tour

Pulp and paper students and professors from the University of Maine at Orono, Me., recently were guests of The Black-

Seated: Walter Rodowski, Black-Clawson consultant on continuous kraft pulping; Prof. C. T. Bockus; I. Soeseno; Dr. Lyle C. Jenness, head of the chemical Engineering Dept. at Maine; W. Ching; S. Wong; Dr. C. W. Thing, Black-Clawson consultant on pulping. Standing: Prof. Andrew Chase; Gustavo Garcia; Giovanni Ciciani; Richard Violette; Jere Crouse; Paul Delekto; Bernt Treu and the tour driver

Clawson Co. at its Pandia pilot plant in Berlin, N. H. This unit of The Black-Clawson Co.'s pulping research is carried on at The Brown Co. in the latter's research and development department.

During their tour of the Pandia pilot installation, the future pulp and paper specialists and their instructors attended a briefing session which included discussion of the principles of operation, the theory of high temperature–high-speed cooking and the results of the research effort. Following this, the group observed the Pandia digester in operation, producing a high quality bleachable grade kraft pulp, using high temperatures, and very short cooking cycles.

Western Michigan University

Dr. John R. Fanselow, a member of the paper technology faculty since 1957, became acting head of the department February 1, until a successor is named for Dr. A. H. Nadelman.

He is an expert in paper machine operation and came to Western Michigan following retirement from the Kimberly-Clark Corp., where he had been assistant to the manager of mills. Joining that firm in 1930, he served first as superintendent of research and from 1936 to 1954 was a staff superintendent.

Dr. Fanselow is a graduate of Ellsworth College, received his M.S. degree from the University of Chicago and his doctorate from the University of Wisconsin. He had nine years of teaching experience before going into industry.

Fifth Annual Paper Conference

More than 250 persons crowded into the Fifth Annual Paper Conference Jan. 19, making it the most successful of such events yet held on the campus.

At least 17 states were represented among the group who heard five technical papers during the morning session, an address by Dr. A. H. Nadelman at noon, and concluding during the afternoon with the panel of five experts answering questions.

Guests were noted from Michigan, New York, Pennsylvania, Wisconsin, Arkansas, Virginia, West Virginia, Ohio, Illinois, New Jersey, Indiana, Iowa, Minnesota, Maryland, Idaho, Alabama, Missouri, and Florida.

Dr. Nadelman provided one of the highlights of the day as he recounted his 25 semesters on the campus. (Dr. Nadelman concluded his service to the University faculty on January 31.)

"Industry seems to have found the school a good investment," he said, "and we have always received generous contributions from the industry."

He reported that during the 12 and one-half years of his service gifts to paper technology had totalled more than $660,000 plus the $125,000 appropriation from the Michigan Legislature, making possible the excellent building and equipment on the campus. This includes $111,668 raised under the direction of R. C. Germanson, chairman of the scholarship committee.

During Dr. Nadelman's tenure on the campus 152 persons graduated in paper technology—with 10 now in graduate school, two in military service, and only three who have left the field for other areas. Dean George E. Kohrman later remarked that this was a fantastic retention record and spoke well of the selectivity of the students and of the training given them.

Dr. Nadelman also expressed great appreciation to the industry for its help in starting Western's paper technology program, and in particular to two individuals, William A. Kirkpatrick, president of Kalamazoo Paper Box, Inc., and Earnest E. Ludwig, formerly vice-president, Bermingham & Prosser Co.

Kirkpatrick spoke for industry, praising Nadelman as a fine teacher and a person respected by the industry.

During the morning session the technical papers included:

Richard C. Porter, S. D. Warren Co., "Beloit Iron Works' Blade." "We have been successful in blade coating with all common pigments and adhesives, provided we keep our solids and viscosities within reasonable limits."

D. E. Bergsma, Senior research chemist, Packaging Corporation of America, "The Steineman Pressure Curtain Coater." "The versatility and unique applications of the pressure curtain coater should make the unit a useful addition to the industry's converting processes."

Karl Halladin, general superintendent, MacSimBar Paper Products Co., "The Levelon Coater." "In our short period of operation we feel that we have developed a coated surface on a bleached food board equal or superior to any printing surface on the market."

C. A. Blaine and H. Mertz, Blandin Paper Co., "The Rice Barton Trailing Blade Coater." "With off-the-machine arrangement, we have been able to absorb the necessary down time for the coater without affecting the efficiency of the paper machine."

C. G. Whelpton, Champion Paper and Fiber Co., "Champflex Coater." "As we gain more experience with the Champflex coater, in trials and mill runs, we are strongly impressed by its versatility and the promise it seems to hold for the future."

Yeshiva University

Three leaders in the paper products industry participated as Master Builders of Yeshiva University in symbolic cornerstone-laying ceremonies on Sunday, March 26, in the University's Nathan Lamport Auditorium, 186th St. and Amsterdam Ave., New York, N. Y.

Max J. Etra of the Star Corrugated Box Co., of Maspeth, N. Y.; Mrs. Louis Koch of the Republic Container Co., Jersey City, N. J.; and Joseph Mazer of the Hudson Pulp and Paper Corp., in New York, N. Y., are members of the Master Builders of Yeshiva University, a select group of individuals, families, organizations, and foundations who have contributed $18,000 or more to Yeshiva University for the purpose of furthering its expansion during the next decade.

Industry Suppliers

Amoco Chemicals Corp.

Frank A. Cassis has been appointed director-sales technical service planning for Amoco Chemicals Corp. and Robert G. Weisz has been named supervisor-sales technical service laboratory. Both Dr. Cassis and Mr. Weisz will continue to be located at the sales technical service laboratory at 3201 South Michigan Ave., Chicago, Ill.

Borden Chemical Co.

Case-Sealing Adhesives

A new technical report on case-sealing adhesives, with complete data on adhesive types, physical properties, common case-sealing problems, and application information, is being offered by the Adhesives & Chemicals Div. of The Borden Chemical Co.

The report, Number G3-101, covers both dextrine and resinous emulsion-type glues. Also included are tables showing the influence of dilution on viscosity characteristics, and technical data such as solids, pH, color, weight per gallon,

L. E. Georgevits, The Borden Chemical Co.

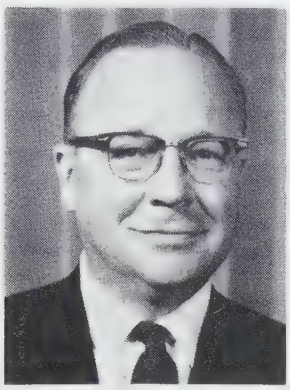
storage life, speed of set, and methods of application for 13 Borden adhesives, specifically designed for modern case-sealing operations.

Staff

Appointment of Louis E. Georgevits to the position of manager of technical sales to the paper industry for the Thermoplastics Div. of The Borden Chemical Co. has been announced by H. C. Wechsler, division vice-president.

Buffalo Forge Co.

The appointment of three vice-presidents of Buffalo Pumps Div. was announced by the Buffalo Forge Co. today. The new officers are: Bruce W. Ellis who has been with the company since 1935 and serves as chief engineer of the Division. Adam E. Hauck, named vice-president of sales, has been with the company since 1923 and became division sales manager in 1958. Henry D. Wilson, appointed vice-president of manufacturing, started with the parent company in 1927, became shop superintendent of the Pumps Div. in 1942 and was made factory manager in 1949.



Bruce W. Ellis, Buffalo Forge Co.

Adam E. Hauck, Buffalo Forge Co.

Chain Belt Co.

After two years of continuous testing and development with plastic bushings in a leading midwest food processing plant, Chain Belt Co. has announced availability of its Chabelco steel conveyor chains with Delrin bushed rollers. The added design feature will aid the Chabelco line in far outperforming the firm's plain all-steel chains that are already increasing wear life over cast chains at a 2 to 1 ratio.

Delrin, a product of E. I. du Pont, is highly resistant to moisture and retains its strength and size when wet. It resists corrosion better than stainless steel and has a low coefficient of friction. Its use in the new rollers, together with noncorrosive stainless steel bushings, offers the ideal combination for maximum service life.

Clinton Corn Processing Co.

In the production of corn sirups, cornstarch is transformed by a chemical process in huge pressure vessels called converters into the sirups which find many commercial uses. The sirup composition may be changed, depending on the extent of the transformation in the converters. Until recent years, chemists have described components of corn sirups rather lossely in terms of dextrose, maltose, higher sugars, and dextrins.

Dextrose is the building block of all the other components. New analytical procedures probe deeper into the composition of corn sirups and show that all component classifications are enlarged.

Maltose, for example, is only one of a group of 13 theoretically possible compounds known as disaccharides. Twelve of these are known. Through the use of the modern analytical tool of paper chromatography, at least eight of these have been found, as well as how much, in one corn sirup.

Analysis of paper chromatography as the name implies utilizes paper—filter paper. The sirup components are separated on filter paper after first placing a very small quantity of the sirup on the paper. Following a period in which the paper is irrigated with a solvent to separate the components in a closed chamber, the positions of the sirup components are located. Their positions identify them. After removal from the paper, their quantities are determined by well-known analytical methods.

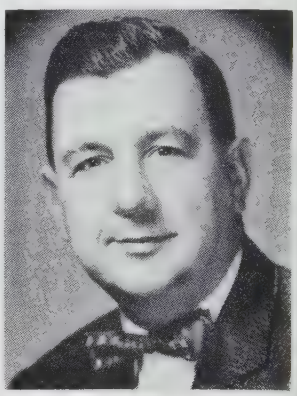
This work done by Dr. Lee D. Ough, Clinton Corn Processing Co., was the basis of a paper presented before the Division of Carbohydrate Chemistry at the St. Louis meeting of the American Chemical Society, March 24, 1961.

Corn Products Sales Co.

The Industrial Division, Corn Products Sales Co., 10 East 56th St., New York 22, N. Y., announces availability of a two-color folder ST-28-10 describing its new flash dried cornstarch for corrugating, Coragum FD. The business-envelope size illustrated brochure covers product, drying method viscosity test procedure, types available, and application advantages.

Dearborn Chemical Co.

Frank Caskey, of Portland, Ore., who has been associated with the paper industry in the Pacific Northwest for 15 years, has joined Dearborn Chemical Co. as a sales representative for Oregon and Washington. Dearborn manufactures industrial water treatment chemicals including its recently patented Super-Filmeen which increases the speed of drying on paper mill rolls.



Frank Caskey, Dearborn Chemical Co.

Eaton Manufacturing Co.

Reliance Division of Eaton Manufacturing Co., Massillon, Ohio, has announced the development and production of a new industrial fastener. Called Torqtite, it is basically a new head design that can be adapted to screws, springtites, or seams.

Torqtite head has three equally spaced driving slots on its outer periphery. This unique feature makes it necessary to use a special tool for driving and, conversely, for loosening. Because of this the fastner is tamperproof and will be used to fasten assemblies where unauthorized tampering might be dangerous. Such items as distributor heads and electrical boxes are ideally suited for the Torqtite. When the Torqtite is driven, the forces are on the outer periphery instead of in the center thus eliminating head distortion through worn driver bits. It offers a greater driver contact area and helps eliminate driver slippage.

Fuller Co.

An improved type motion safety switch for protecting machines, equipment, and processes against damage resulting from stoppage or reduced speed is described and illustrated in a new two-color, 4-page bulletin (MS-3) now offered by Fuller Co., Catasauqua, Pa.

General Aniline & Film Corp.

General Dyestuff Co.

Robert J. Holmes has been named to the newly created

position of acting product manager of the Blancophor product line (optical brighteners for use in the soap, textile, and paper trades) at General Dyestuff Co., a Division of General Aniline & Film Corp., 435 Hudson St., New York, N. Y.

General Electric Co.

Digital Telemeter System

Bulletin GEZ-3312, four pages, describes General Electric's fast 100% accurate telemetering of kilowatt-hour readings from remote locations to central load dispatch office. Bulletin relates operating features of digital telemetering systems with descriptive schematics, system specifications, and available accessories.

Silicones for Release Paper Coatings

A new 16-page illustrated bulletin describing the complete line of General Electric silicone coatings for release paper is now available from the Silicone Products Dept. of General Electric, Waterford, N. Y.

Entitled "Silicones for Release Paper Coatings," the bulletin (S-11) describes three emulsions, four solvent solutions, and two controlled release additives for application from solvent, all designed to meet the varying needs of the paper industry. The bulletin is intended to complement an earlier publication, "Silicone Coatings for Paper Release Mechanisms," which deals with the chemistry of silicone release paper coatings.

Included in the publication is important technical information pertaining to the use of additives and descriptions of techniques for application and evaluation of silicone release coatings as well as tips on the care of equipment used to apply silicone coatings.

Switchboard Instruments

Bulletin GEZ-3308, 12 pages, describes General Electric's new low cost, 1% accuracy, type AB-30 and DB-30 switchboard instruments which offer savings of 10 to 20%. Information relating to ranges covered, instrument burden data, dimensions and panel drilling layouts plus external connection diagrams and other pertinent specifications are shown.

Harris-Seybold Co.

Harris-Seybold has become the exclusive distributor in the United States and Canada for the Stevens line of automated finishing room equipment according to a recent announcement by Charles R. Stevens, Inc., and Harris-Seybold, a division of Harris-Intertype Corp. The line includes automatic unstackers and trimmer loaders, finished skid stackers, levellators, skid lifts, and related sheet handling devices. The new, automated machinery is designed to increase the efficiency of mill trimmers through faster mechanical sheet handling operations. A number of installations in the finishing rooms of paper mills have already been reported.

The new equipment will continue to be manufactured by Charles R. Stevens, Inc., Maumee, Ohio.

Hercules Powder Co.

Aid-to-Education Program

Hercules Powder Co.'s aid-to-education program will provide American universities and colleges with an estimated $280,000 during 1961, it was announced. This is approximately the same amount distributed in 1960.

Thirty-two different United States institutions of higher learning will share in the $119,000 Hercules is allocating for unrestricted grants-in-aid. Recipients of these funds have complete freedom in determining the manner in which the grants will be used.

Approximately $125,000 will be expended by the chemical company to finance the cost of specific on-campus research projects usually conducted by graduate students. The remaining monies in this year's aid-to-education program will support Hercules' matching-grants program, three other financial awards made annually by the company's Paper Makers Chemical Department, and the firm's participation in the National Merit Scholarship Program, which makes two-year college scholarships available to children of company employes.

Staff

Four new managerial assignments in Hercules Powder Co.'s Paper Makers Chemical Dept. have been announced by John H. Long, general manager of the department. The new assignments are: Arthur E. Drake, director of development, Robert W. Little, sales manager rubber chemicals, W. Donald Thompson, manager of sales service paper chemicals, and Spencer H. Watkins, assistant manager of sales service paper chemicals.

J. M. Huber Corp.

J. M. Huber Corp. has established an office in Syracuse, N. Y., for the sale of clays and pigments to the paper industry. The office is located at 15 Centennial Drive, and is headed by Robert T. Larkin.

Huber now has sales offices serving the paper industry in Appleton, Wis.; Baton Rouge, La.; Houston, Tex.; Kalamazoo, Mich.; Macon, Ga.; New York, N. Y.; Syracuse, N. Y.; and Watertown, Mass.; all of which are in or near large paper producing areas.

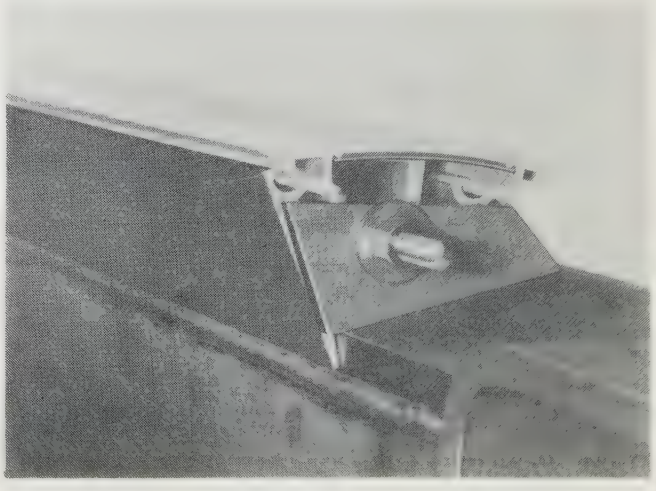
Lodding Engineering Corp.

Fourdrinier Wire Doctor

A new adjustable hydrofoil, the Lodding fourdrinier wire doctor, has been introduced by Lodding Engineering Corp., Auburn, Mass., the nation's leading manufacturing specialists of paper machine doctors and component parts.

Specifically engineered as replacements for table rolls, wire doctors are designed to eliminate the pressure ridge that is generally associated with table rolls, and to maintain a control over drainage from the wire to a degree not possible with table rolls. Also, snap back of the fourdrinier wire is minimized, all of which results in improved sheet formation.

The wire doctor consists of a stationary, semirigid extruded cover, head assembly to provide for adjustment of the cover, a support beam and brackets for mounting. In operation the cover's beveled leading edge both supports the wire and skives water from its underside. Camber of the cover can be freely adjusted while the machine is running



End view of the wire doctor head assembly showing the cover with flexible metallic reinforcing strip and stud for regulating horizontal movement

to regulate the amount of drainage induced by vacuum through the wire. Comparable flexibility with table rolls can be achieved only through substitution of rolls of differing diameters.

Drainage induced by a wire doctor is generally comparable to that of a table roll. Since wire doctors may be installed on a minimum of 6-in. centers, it is usually possible to replace table rolls with a greater number of wire doctors, thereby increasing the overall drainage capacity of the fourdrinier.

Manufactured under license from Dominion Engineering Works, Ltd., of Montreal, Lodding wire doctors are available for all machine widths and speeds. Bulletin No. 6105 describes the wire doctors in detail.

Monsanto Chemical Co.

An improved resin to impart water resistance to coatings for offset printing paper manufactured on high-speed machinery has been introduced by Monsanto Chemical Co.'s Plastics Div. The product, tradenamed Scriptite 31, is a colorless water solution of methylated methylol melamine resin. It is especially suited for high solids coatings, where increases in viscosities cannot be tolerated. Added to the binder system for pigment coating formulations, Scriptite 31 links with the protein or latex base to form a tough, water-impervious coating. The amounts to be used will depend on the drying time and temperature and the degree of wet-rub desired.

Nopco Chemical Co.

Walter E. Brewer has been named to the newly created post of general sales manager for the Industrial Div. of Nopco Chemical Co., Newark, N. J. The appointment was announced by J. N. Gammon, vice-president in charge of Industrial Division sales.

Nopco's Industrial Division produces vital chemical ingredients for a wide range of processes and manufacturing operations in such industries as textile, paint, leather, rubber, cosmetics, petroleum, and metalworking.

Ohmart Corp.

A new six-page two-color fold out folder describes details of basic systems employing nuclear gages for controlling specific gravity or density and liquid or interface levels. Fundamental ideas of using gamma radiation are described as well as components required for a complete system. Schematic diagrams visualize installations and photos show equipment. Methods of zero suppression, use of associated instruments, temperature regulation, safety, and calibration and maintenance are detailed.

Copies of the new nuclear control systems may be obtained from The Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio. Bulletin No. 105-C.

Olin Mathieson Chemical Corp.

Olin Research Center

There are approximately 600 scientists, engineers, and technicians at the $7,500,000 Olin Research Center recently dedicated in New Haven, Conn., where the company has concentrated all its organic and inorganic chemicals, fuels and propellants, explosives, packaging film, metals, firearms and ammunition research. During the past two years, Olin has spent nearly $3,000,000 on improvement of facilities and consolidation of these activities at New Haven. The corporation's pharmaceutical and biological research has been consolidated at The Squibb Institute for Medical Research in New Brunswick, N. J.

Its diversity of equipment and projects make the New Haven research facility unique in industry. The laboratories are equipped to investigate reactions from sub-zero to several thousand degrees Fahrenheit and under pressures of 3 mm. or tens of thousands of pounds. Olin researchers can separate and identify impurities in less than one part in 10,000,000 or produce hundred-pound samples for evaluation by customers or applications laboratories. Using the most modern machines and techniques, they can measure the useful life of antifreezes in automobile radiators, develop welding methods; cast, extrude, and coat films; test freshness of foods; evaluate exotic fuels for rockets and missiles; create new urethane foam compositions; finish metals; and even try to find out what type of shotgun will give the sportsman of the future the most pleasure.

Reliance Electric & Engineering Co.

Catalog G-100, a new 88-page publication covering the complete line of Reeves Vari-Speed Motodrives, $^1/_4$ through 40 hp., is now available from Reliance Electric and Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.

Data in the catalog include full rating tables, with new additional output speeds. Dimension diagrams and charts for over 100 different assemblies, new higher overhung load and new controls, are also contained in this new catalog.

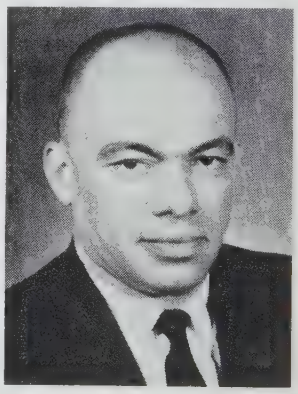
Rhodia, Inc.

A booklet describing a unique method of chemically eliminating objectionable odors resulting from industrial processing and municipal sewage operations has been published by Rhodia, Inc., New York, N. Y. Through an inexpensive process, specially tailored chemicals are blended with the source of the odor problem to create a clean, fresh, pleasant quality, with almost no discernible trace of either the original odor or the chemicals.

Rice Barton Corp.

The promotion of Jean W. Rohm to chief engineer in charge of research and development of Rice Barton Corp., Worcester, Mass., was announced by Donald B. DeNoyer, vice-president of engineering of the 124-year-old papermaking machinery firm.

In his new capacity Mr. DeNoyer stated that Mr. Rohm will utilize Rice Barton's new $100,000 laboratory for the development of new products for the pulp and paper industry. Reflecting another move toward providing mills with improved equipment Rice Barton's stepped-up research program is concentrating on specific papermaking and accessory projects.



Jean W. Rohm, Rice Barton Corp.

William E. Bright, III, has been named manager of customer service of Rice Barton Corp., Worcester, Mass., it was announced by Charles S. Barton, president, and Frederick T. Coker, executive vice-president. Mr. Barton stated that Rice Barton has combined all estimating, proposal engineering, service, and outside erection in this single office to improve the handling of customer inquiries and service to the mills.

Roots-Connersville Blower Div.

Roots-Connersville Blower, Div. of Dresser Industries, has added a 7000 CFH (168M CFD) Model 7M125 to its line of rotary positive displacement meters. The new line-mounted Rootsmeters are recommended for production, transmission, distribution, intraplant or institutional gas measurement at pressures to 125 p.s.i.

S & S Corrugated Paper Machinery Co.

Albert Shields, vice-president in charge of engineering, an-

nounced the appointment of Oscar Kleinman as chief engineer at S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y.

Sprout, Waldron & Co.

The availability of an Advance Specification Sheet (No. 229) giving details on Moyno pump conveying systems for conveying fine powdery materials without dusting problems is announced by Sprout, Waldron & Co., Inc. The unique helical rotor design of the pump forces the material through a stator section where a small amount of air can be bubbled into the stream to fluidize the material so it flows very much as a liquid would flow.

Stowe-Woodward, Inc.

A new data page giving information about the firm's suction press roll coverings has been published by Stowe-Woodward, Inc. In addition to providing technical information about S-W suction roll covers, the literature claims that improved bonding methods have been developed through the years to cope with changing conditions in papermaking.

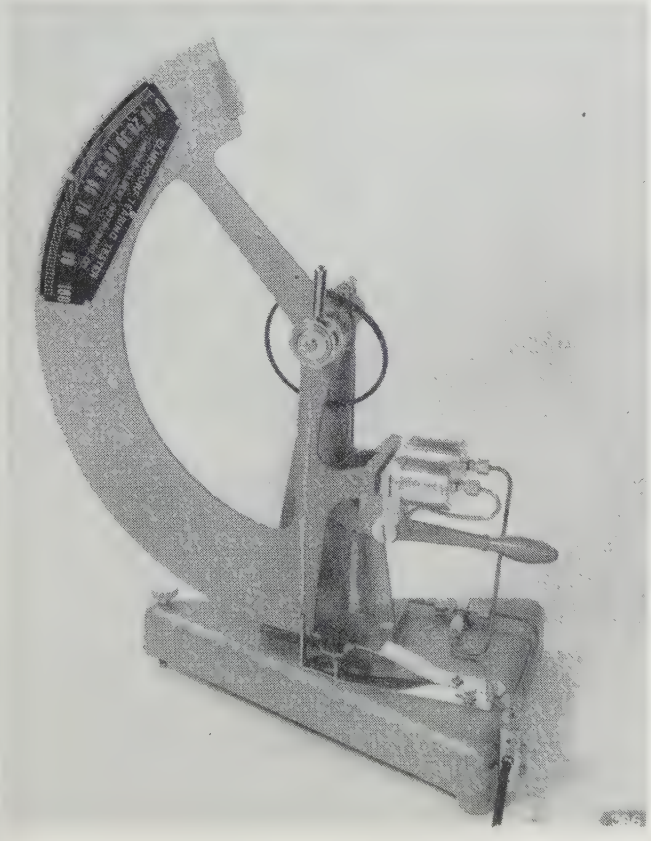
Testing Machines, Inc.

A catalog is now available illustrating and describing a complete line of plastics products for laboratory and plant. The booklet covers items ranging from instrument dust covers (flexible vinyl or rigid acetate), protective garments, and heavy duty nonbreakable laboratory supplies. This catalog shows hundreds of plastic vessels, fittings, safety coverings, dispensers, containers, and graduates and has many safety applications and time saving ideas. For a copy write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Thwing-Albert Instrument Co.

Air Grips for Elmendorf Tearing Tester

Thwing-Albert Instrument Co. announces the development of new air-operated grips for the Elmendorf tearing tester.



Elmendorf tear tester with air grips

The new air-operated grips enable an operator to test twice as many samples in less time with greatly reduced operator fatigue. Samples can be inserted and removed in one easy operation without turning any screws. Air pressures as low as 15 pounds assure uniform clamping pressure on the sample at all times and can be installed on existing Elmendorf.

General

Reproduction Paper News Bulletin

The *Reproduction Paper News Bulletin* is published by the Andrews Paper & Chemical Co., P.O. Box 528, 676 Northern Blvd., Great Neck, N. Y., as a service to the reproduction industry four times a year. They are being sent free of charge to people engaged or interested in reproductions. They would be glad to put on the mailing list any who express an interest.

1960 U. S. Per Capita Paper Consumption—431.4 lb.

	1959	*1960*
Production ('000's)	34,007	34,282
Imports ('000's)	5,609	5,716
Exports ('000's)	919	1,021
Consumption ('000's)	34,697	38,977
Population, Millions	177.3	180.7
Per capita consumption, lb.	436.5	431.4

Source: American Paper and Pulp Association.

OBITUARIES

G. Elmer Emigh

G. Elmer Emigh, who had served as sales engineer in the Southern West Coast area for The Sandy Hill Iron and Brass Works since his retirement from the paper industry in 1954, died on March 4 at his home in South Gate, Calif.

During his many years in the paper industry Mr. Emigh gained considerable prominence. He held positions as assistant superintendent and superintendent for such companies as International Paper Co., Crown Zellerbach, St. Helens Pulp and Paper Co., Filer Fiber Co., and Pioneer Flintkote Co.

H. A. Helder

H. A. Helder, 74, retired vice-president and Carolina division manager of Champion Paper and Fibre Co., died at 6:45 p.m., Jan. 22, 1961, in a Waynesville hospital after an extended illness.

Mr. Helder was a native of Dallastown, Pa. He received his B. S. degree in chemistry from Pennsylvania College at Gettysburg in 1908 and joined the Champion firm in Canton the same year.

He was promoted to chief chemist in 1924 after serving as superintendent of the extract department for four years. He was then elevated to technical director of the Canton division, in which capacity he remained until 1937, when he was made assistant mill manager.

In 1939, Mr. Helder was promoted to mill manager, and in 1946 was named Canton manager.

Mr. Helder was named vice-president and Carolina division manager of the company, in 1952.

He retired in 1958 after 50 years with the company, and was a member of the Technical Association since 1924.

Surviving are the widow, Mrs. Adah Clark Helder; and a niece, Mrs. Richard Avery of Camp Hill, Pa.

DIVISIONS AND COMMITTEES

Authorized Committee Assignments

The following new assignments initiated in committee during the month of March, 1961, constitute the continuing association activities of the committees indicated. These TAPPI assignments are activities that are carried on in addition to the planning of meeting programs. The TAPPI numbers assigned cover the committee work performed in connection with conferences, monographs, standards, data sheets, routine control methods, special reports, conference papers, etc. These numbers are assigned by TAPPI Headquarters.

Assignment No.	*Committee*	*Title and objective*	*Committeeman in charge of assignment*
		COATING AND GRAPHIC ARTS DIVISION	
1004	Graphic Arts	"The Proof Press and Printing Quality" to produce routine proof press control tests for major attributes contributing to printability.	F. C. Oppen
1005	Graphic Arts	"Definition of Terms in the Paper Printing Area" to produce useful definitions and get them accepted throughout major areas of the paper and printing industries.	F. C. Oppen
1006	Graphic Arts	"Surface Strength Evaluation" publication of an official TAPPI standard method for surface strength.	A. Glassman
1007	Graphic Arts	"Transfer and Penetration Aspects of Ink Receptivity" to improve our basic understanding of ink transfer and penetration as a basis for eventual improvement of TAPPI Standard Test Methods in this area.	W. C. Walker
1008	Graphic Arts	"Graphic Arts Committee Operating Manual" to write and to keep up to date a manual that will help committee members understand the structure and function of the TAPPI Graphic Arts Committee.	H. J. Connell
		CONVERTING AND CONSUMING DIVISION	
2000	Wet Strength and Interfiber Bonding	"Research Proposal Covering Location, Identification, and Effects of Synthetic and Natural Resins on or in Paper Fibers" to determine effects on strength and defects in paper correlated with location of resins.	R. E. Schmut
2001	Wet Strength and Interfiber Bonding	Research Proposal—"Mechanism of Wet Strength Development with Polyethylene-imine" to supervise the application for such study and to maintain liaison with the project if and when it is undertaken.	A. C. Schmalz
		CORRUGATED CONTAINER DIVISION	
3001	Process and Quality Control	"Top to Bottom Compression as Related to Combined Board Tests" find a new relationship for predicting top to bottom compression of corrugated containers from combined board tests.	H. J. Ostrowski
3002	Process and Quality Control	"Corrugated Container Construction in Relation to Automatic Set-Up Equipment," to determine the construction requirements for corrugated containers for efficient operation through automatic setup equipment.	E. Carpenter
		ENGINEERING DIVISION	
4005	Operations Research Subcommittee	"Joint Seminar (with APPA) in Operations Research" to sponsor a seminar on operations research for paper industry executives at the 1962 Paper Week. The objective of this seminar will be to inform executives of the usefulness of operations research in various aspects of industry, especially in cost reduction projects.	T. A. Hewson
4006	Operations Research Subcommittee	"Bibliography on Operations Research" to collect information on books and articles on operations research for the benefit of operations research men in the paper industry.	C. E. McCarty
4007	Operations Research Subcommittee	"Computer Program Information Sheets" to study the need for technical information service to TAPPI members in the area of digital computer programming. Also to recommend a feasible procedure.	D. S. Hoag
4008	Drying	"Temperature Measurement Methods for Drier Surfaces and Webs" to describe, determine limitations and evaluate effectiveness of methods, etc.	L. R. Vianey
4009	Drying	"Standard Nomenclature for Expressing Moisture Content of Dryness with Some Means of Conversion of Current Terms" clarify the various expressions for moisture content.	R. E. White
4010	Drying	"Survey of Energy Coats in the Drying of Paper and Coating" to determine the energy costs for drying paper and coating by various commercial methods. This information should be developed for various moisture ranges of paper and coating where data are available.	S. G. Holt
4011	Sanitary Engineering	"Annual Literature Review of stream pollution and waste treatment pertaining to pulp and paper industry" present a brief résumé of published literature, in summary form, covering current developments in the field for the purpose of keeping industry personnel informed.	N. J. Lardieri
4012	Sanitary Engineering	"Unique Methods for Waste Flow Measurement" outline and illustrate unique methods for flow measurement of waste effluents, particularly for use where classical methods do not lend themselves because of physical limitations or costs are too great for the nature of the flow measurement program.	R. W. Simpson
4013	Sanitary Engineering	"Glossary of Water and Waste Control Engineering" compile dictionary of terms, with definitions, used in the field of water and waste control engineering for purpose of eliminating confusion as to interpretation.	
4014	Electrical Engineering	"The Modernization of an Entire Power Distribution System in an Existing Integrated Pulp and Paper Mill" to stimulate interest by the full industry of the power distribution engineers problems in the continual expansion of plants.	S. A. Bobe

4015	Electrical Engineering	"Equipment Grounding for Safety" to clarify the wide variations in recommended grounding practices for the paper industry. (Revision of C. A. No. 862.)	S. A. Bobe
		Pulp Manufacture Division	
6001	Alkaline Pulping	"1964 Eighteenth Alkaline Pulping Conference"	
6002	Deinking	"Seventh Deinking Conference 1962"	
6003	Deinking	"Eighth Deinking Conference 1963"	
6004	Chemical Products	"Monograph on Crude Talloil Manufacturing" (with or without Sulfate Turpentine Manufacturing), to investigate the feasibility of a monograph on talloil, soap skimmings, and related subjects with or without the inclusion of turpentine. If feasibility is affirmed the scope of the monograph would be limited to the requirements of the operating technical and engineering supervisor working or preoccupied in this field and comprise such topics as technical know-how, analytical procedures, specifications, description of equipment commonly used, etc.	P. B. Borlew
		Testing Division	
8010	Pulping and Papermaking Chemicals	"Color Strength & Shade of Dyestuffs" revise T 626 sm-43	M. Hayek
8011	Pulping and Papermaking Chemicals	"Dextrinizing Value of Enzymes" (Enzyme Activity) revision of T 643 sm-54	D. A. Hughes
8012	Pulping and Papermaking Chemicals	"Analysis of Sulfur T616" rewrite procedure for analyzing bulk sulfur	P. T. Comiskey
8013	Precision; Paper S/C T	"ASTM-TAPPI Joint Task Group on Sampling" revise TAPPI 400 -m and ASTM D585	T. W. Lashof
8014	Pulp Testing	"Fiber Length of Pulp by Classification, T 233 sm-53" to revise method	J. d'A. Clark

Local Section Operations Committee

Executive Committee Actions

P. E. Nethercut, serving as chairman, opened the meeting at 3:00 p.m., Feb. 22, 1961, with a review of February 19th Executive Committee decisions affecting local sections and districts.

The 1961 Pacific Section seminar to be held next fall will be taught by A. Stamm of the North Carolina State College staff. The Association will not attempt to combine his trip to the West Coast with other local section speaking engagements en route, as had been done in 1960 for Dr. Lennart Stockman of Sweden. It is felt that speaking tours of this type might be arranged in the future for overseas lecturers who may be of interest to several local sections.

Local sections interested in proposing nominations for the TAPPI Medal are urged to transmit their suggestions promptly to F. S. Klein, Byron-Weston Co., Dalton, Mass., chairman of the Awards Committee. Nominations should be accompanied with sufficient supporting information to enable the Awards Committee to evaluate each proposal.

Similarly nominations for the fall election of TAPPI president, vice-president, and new Executive Committee members (succeeding W. C. Bloomquist, F. S. Klein, L. G. Rolland, and H. O. Ware) should be submitted to J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me., who is chairman of the Nominating Committee.

The Association is considering the establishment of a TAPPI group in the Los Angeles area and plans to hold an organizational meeting there in the spring to discuss this proposal.

TAPPI officers and Executive Committee members are planning to attend many of the local section and district meetings this spring as representatives of the President and the Association.

Headquarters Aids to Local Sections and Districts

A revised edition of the 1957 "Manual for the Guidance of Local Sections and Districts" will be published in May *Tappi*, and reprints will be distributed to all local section and district officers. The chairmen will be asked at that time if they require additional copies for their key committees.

The staff will also publish in May a speakers list to aid program chairmen in planning their 1961–62 meetings. This list will indicate if a speaker has presented a similar paper at another meeting, so that a program chairman will know whom to approach for first-hand information on the contents and quality of the paper.

After a discussion of the limited use of paper industry films at local section meetings, it was agreed that the staff would not prepare a film list for program chairmen. A 1959 APPA list of movies and film strips can be obtained from the headquarters office upon request.

Local section and district treasurers were urged to submit their requests for rebates prior to December 1 of each year, so that payments can be made during the calendar year.

J. Lewis described the successful membership drive of the New England Section, using envelopes addressed by the headquarters office to all Association members living in the New England Section's area. Other local sections were invited to request similar headquarters assistance for their own membership promotion efforts.

Deadlines for the submission of copy to *Tappi* were reviewed. The staff will be greatly pleased to print advance publicity on local section meetings, provided that it is received in time. *Tappi* is mailed between the 10th and 15th of each month. The deadline for copy is the 25th of the second month preceding the month of issue, i.e., roughly 40 days before mailing. Occasionally it is possible to insert small notices received after this deadline, but this can never be assured in advance.

Reports written and submitted following the meeting are normally published without delay, unless a paper must be reviewed by the Editorial Board for possible publication in the *Tappi* Technical Section.

W. R. Brandt asked that all requests from the Association be written with specific information on dates, printing requirements and whatever else may be involved, so that the local section officers will understand clearly what is requested.

Local Section Activities

T. Porowski described the recent membership drive of the Chicago Section, whose membership has been raised from 175 to over 300 in the past year. Many of the new Chicago Section members were members of TAPPI who were located through a geographical roster in the Yearbook.

C. Sweitzer reported that the Ohio Section program chairman received many program recommendations from a "suggested topics" and "suggested speakers" questionnaire printed on the reservation card mailed to members before each meeting.

Several chairmen commented on the usefulness of news announcements they received from other local sections.

This exchange of information is considered so valuable that each local section is urged to place the names of the chairmen of the other sections on its mailing list. These names are listed in the Local Sections Directory, which may be obtained from the headquarters office.

The committee discussed TAPPI's publication policy for papers presented at local section meetings. When submitted to the Association, such papers are usually published promptly in *Tappi*, but presentation of the paper at a TAPPI local section meeting does not guarantee its publication in *Tappi*. Such decisions are made by the *Tappi* editor.

It is the prerogative of the local section officers to release a paper for immediate publication in other magazines if they choose. Prior publication elsewhere may, however, reduce the likelihood of its acceptance for *Tappi*.

Committee members were informed of a 1958 Executive Committee decision that local sections should not sell advertising space in their publications. Some sustaining members had objected at that time to requests for what they felt were unreasonable amounts.

The committee also discussed the article in the TAPPI Constitution stipulating that local section officers must be TAPPI members. To prevent any possible embarrassment incoming local section officers should be acquainted with this requirement before they assume office.

There was a lengthy discussion of local section award competitions. The Worthen E. Brawn Award of the Maine-New Hampshire Section and the E. J. Albert Award of the Delaware Valley Section have not been held for two years because of the lack of entrants. The Kalamazoo Valley Section relies on students from Western Michigan University, and the New England Section bases its competition on students from Lowell Tech. The Southeastern Section has continued to obtain more than enough entrants (11 papers last year). It has no age limitations, but the participants must be mill people rather than suppliers. According to Bob Flick and Bill Reaves much of the success of the Southeastern Section's competition can be attributed to the members of their own Executive Committee, who represent the major mills in their area and who contact their top managements directly for support of this competition.

PHILIP E. NETHERCUT, *Executive Secretary*

Coating and Graphic Arts Division

Coating Committee

The meeting was opened at 2:30 p.m. Feb. 20, 1961, in New York by J. E. Wilber, who then called on R. T. Trelfa, Coating and Graphic Arts Division chairman. Mr. Trelfa read Jack Wilber's letter of resignation which included a recommendation that C. G. Landes be appointed as chairman of the Coating Committee. This recommendation was approved by Mr. Lientz, president of TAPPI, and Mr. Landes was appointed chairman.

With Mr. Landes presiding, his first suggestion was a vote of appreciation from the Coating Committee to Mr. Wilber for his work as chairman of the committee, as well as his time spent as a member of the Coating Council and work on various subcommittees. The Coating Committee concurred with the chairman's suggestions.

MINUTES

Moved and passed to accept minutes of last meeting (May 23, 1960) as mailed to committee members.

CHAIRMAN'S REPORT

Mr. Wilber presented his report for the past year.

REPORT ON RESEARCH PROJECT NO. 536

Professor Durst of the University of Maine gave a short report on the work that has been done to date. He concluded

Coating Council Meeting, Feb. 19, 1961: C. G. Landes, North Carolina State College of Agriculture and Engineering; R. W. Hagemeyer, Wyandotte Chemicals Corp.; A. J. Winchester, TAPPI; J. E. Wilber, St. Regis Paper Co., chairman; R. T. Trelfa, Perkins Goodwin Co., chairman, Coating & Graphic Arts Div.; R. W. Martinek, Kimberly Clark Corp.; F. Kaulakis, Consolidated Water Power & Paper Co.

his remarks by indicating that they need additional funds of approximately $5200 to continue the work using starch as the adhesive, with the thought in mind of presenting a paper covering this work at the coating conference in 1962.

Glenn Hemstock, who heads the subcommittee that is providing guidance for this project from the Coating Committee, recommended to the committee that this work be continued. Mr. Wilber, who as chairman was responsible for requesting the past research appropriation, suggested that the Coating Committee ask for a research appropriation not to exceed $5400 to continue this work. A. D. Bonnano made a motion to this effect, seconded by Jack Leech, and was passed unanimously by the committee.

COATING MONOGRAPHS

Chairman Landes commented that out of 22 TAPPI Monographs, nine of them had been sponsored by the Coating Committee. . . an enviable record. There was currently two monographs being actively promoted, with others under consideration.

Assignment No. 303—Monograph on Paper Coating Adhesives. No report.

Assignment No. 796—Monograph on Pigmented Coating Processes for Paper and Paperboard. George Booth commented that he will submit a formal report in ten days. Currently, they are in need of authors on the use of air doctors for the coating of bleached board and folding board, and also on the use of blade coaters for bleached board and folding board. They have been completely unsuccessful in lining up an author for a chapter on cast coating.

SUBCOMMITTEE REPORTS

Assignment No. 910—Adhesive Studies—M. L. Cushing. Mr. Cushing distributed a progress report covering the work of his subcommittee. While he has received good support from the various adhesive suppliers, he needs more help, particularly from mill people in the way of suggestions or ideas that can develop into research projects on paper coating adhesives.

Assignment No. 911—New Projects—J. Frankevicz. Mr. Frankevicz commented that his committee is working in two areas. First, they are studying the advisability of the Coating Committee sponsoring a monograph on calendaring and finishing; and second, they are evaluating a suggestion

by Alex Glassman that the Coating Committee consider a project on the subject of "What Do Coating Components Contribute to Paper-Ink Interface Surface Activity?" Mr. Frankevicz commented that the committee had not had sufficient time to completely evaluate the two proposals; but he expected they would have the work finished and make definite recommendations by the next Coating Committee meeting in May, 1961.

Assignment No. 913—Pigment Studies—W. R. Willets. Mr. Willets reported that the subcommittee is still investigating possible ways of instigating a research project in the pigment area. The proposal from Armour Institute appears to be the best date, however, there is a considerable sum of money involved.

Assignment No. 913—Factors Affecting Coat Weight—R. J. Jacobs. Mr. Jacobs reported that the members of the Coating Committee had not responded to his original questionnaire on the above subject. It was felt that the original project had too broad a scope; and, as a result, the Coating Council had redefined the area to be covered, restricting it to a compilation of the above factors for air knife coaters.

A member of the subcommittee, Mr. Willenbrocke, distributed an outline listing various factors which affect coat weight, using the air knife coater. It is hoped that the members of the Coating Committee will carefully review this outline and pass along any comments to Mr. Jacobs.

New Projects Committee—J. Frankevicz. As a result of recommendations by the New Projects Committee, the following two projects were instigated:

1. Carl Kessler was appointed chairman of a committee to compile and circulate a list of projects to various graduate schools and universities to stimulate graduate work in the paper coating area. Mr. Thomas suggested that Mr. Kessler investigate the activities of the APPA and TAPPI in this project area. He also called attention to several articles which appeared in the January, 1961, issue of *Tappi*, pointing out the importance of the paper industry, and also its research and employment possibilities.

2. Hugh Lavery was appointed chairman of a subcommittee to study "The Effect of Pressure in the Coating Unit on the Rheology, Penetration, and Other Properties of Coating Colors."

Coating Conferences

Mr. R. W. Martinek reported on the future Coating Conferences as follows:

1961 Coating Conference—Statler Hilton Hotel, Buffalo, N. Y., May 8, 9, and 10, 1961. The theme for this Coating Conference is "Adhesives for Coating." C. G. Welpton, of Champion Paper, is program chairman. Practically all of the arrangements, so far as the technical program and mill visits, have been completed.

1962 Coating Conference—Netherlands Plaza Hotel, Cincinnati, Ohio. C. G. Whelpton is the conference chairman; W. E. Welliver, program chairman.

1963 Coating Conference—Concord Hotel, Kiamesha Lakes, N. Y. This conference was orginally scheduled for French Lick, Ind., but had to be relocated because of a lack of adequate facilities at French Lick.

1964 Coating Conference—New Orleans, La. Hotel to be determined.

1965 Coating Conference. Conference to be held on West Coast, preferably in Pacific Northwest; however, if facilities are not available in this general area, San Francisco will be the alternate site.

Data Sheets

A formal report from L. E. Georgevits had been previously circulated to the committee. He commented that the pigments and adhesives subcommittees were making excellent progress in assembling data for publication. R. N. Zabe, who has been trying to accumulate engineering data, has had little or no success in obtaining information from the various paper mills. Mr. Georgevits pointed out that other divisions were publishing this type of information and made an urgent request that Coating Committee members who have such data available forward it to Mr. Zabe.

Liaison Reports

ASTM D-25—J. Voit. A copy of Mr. Voit's progress report had been circulated to the Coating Committee members. Mr. Voit announced that the next meeting of the ASTM Committee was to be held on February 24, and all interested members were urged to attend.

Routine Control Methods—R. Bashford. J. R. Gunning had previously served in this capacity and asked to be relieved of this duty. Ray Bashford, of Penick & Ford, has been appointed to replace him. In Mr. Gunning's last report, he mentioned that he was receiving a number of methods from the various suppliers, but would appreciate a few routine control methods from the paper mills.

Coating Council

C. G. Landes, chairman of the Coating Committee, appointed the following members of the Coating Council and also defined their duties:

Vice-Chairman, Frank Kaulakis—Coating Committee Projects
Secretary, R. W. Hagemeyer—Minutes, Membership, Monographs
Senior Member, R. W. Martinek—Data Sheets, Liaison
Junior Member, C. G. Whelpton—Future Coating Conference

As chairman, C. Landes has the responsibility for preparing requests for research appropriations.

New Business

1. Mr. Wilber reported that he had appointed a subcommittee to be headed by J. J. Thomas to study the Coating Committee and Coating Council as regards the structure and method of operations.

2. Mr. Jacobs suggested a committee to investigate authenticity of advertising claims made by paper mills or suppliers in the paper coating area. In subsequent discussion, it was brought out that such a policing action was outside the jurisdiction of the Coating Committee and should properly be handled by TAPPI Headquarters.

3. C. G. Landes outlined his program for 1961–62: (a) complete all active projects during the coming year, (b) complete all active monographs during the coming year, and (c) initiate new projects to get more Coating Committee members active in the work being carried on.

R. W. Hagemeyer, *Secretary*

Coating Committee Annual Report

In the period from February, 1960, to February, 1961, the Coating Committee, under the direction of the Coating Council, and with the guidance and support of the parent division, continued a pattern of growth and increasing accomplishment. A year ago, Joe Loomer indicated to you an active membership of 86. In the past year, this figure has increased to the neighborhood of 110.

Maintaining an active and contributing membership of this size can be a task of great proportions. Recognition of this problem was in large measure the factor responsible for establishing several years ago, the "council" form of committee administration. I would like to take a few moments to explain certain of the functions of the Council.

The council now comprises five members; a chairman, vice-chairman, secretary, senior member, and junior member. The committee chairman is also chairman of the Council. The remaining members are appointed by the chairman. In addition to being a policy making group, each member has the administrative responsibility for various phases of committee activities as designated by the chairman. These members can

and do act for the chairman with full authority in their respective areas.

In the last year a first "Operating Manual" was prepared and distributed. While subject to continuing modification, it presents the general responsibilities and duties of the Council members.

With the splitting of responsibility for committee activities among five individuals, the tasks, while easier, remain at times onerous. As befits the members of a professional organization such as TAPPI, the Council members in the past year have given unstintingly of their personal and professional time to advance the interests of the committee. For this, I wish to acknowledge with great appreciation, the contributions and efforts put forth by Chet Landes, Frank Kaulakis, Bob Hagemeyer, and Dick Martinek in the last year.

In addition to the two full committee meetings in the past year, the Council met (often in a healthy atmosphere of disagreement) on five different occasions for a total of 8 full days of deliberation. The locations were Chicago (2), Buffalo, Atlanta, and New York.

To insure continued growth and efficiency, and in the interests of self-discipline, a subcommittee has been recently appointed to review the structure and *modus operandi* of the committee. This group will report to the chairman, recommendations for any modifications or improvements in administrative organization that may be deemed beneficial.

The agenda for this meeting lists 16 active committee assignments, each with established subcommittees except the Fourteenth and Fifteenth Coating Conferences. Using a conservative figure of four members per committee, it is apparent that approximately 50% of the membership are active in project work. While this is encouraging, our objective is to increase this figure. May I urge each of you to acquaint yourselves with the active assignments and the respective subcommittee chairman. They will appreciate your interest, your thoughts, or your suggestions.

Progress on committee assignments in the reporting period has been significant in all cases, though some have been trying. The subcommittee chairman and/or responsible Council member will cover these in detail later in the meeting. With reference to all assignment chairmen, I wish to single out three areas where progress or achievement have been particularly gratifying.

Project 569, the revision of "Synthetic and Protein Adhesives" monograph was successfully complete with the issuance of TAPPI monograph number 22 this month. Lloyd Silvernail and Walter Bain are to be sincerely congratulated for an outstanding job.

Project 536, TAPPI sponsored research "Study of Flow Properties of Coating Colors" has reached a stage of real progress as will be discussed in detail by Dr. Durst of the University of Maine, and Glen Hemstock. The Steering Committee comprised of Dr. Hemstock, Mattson, and Robinson have devoted their time and efforts tirelessly to achieve this point. To them, our special thanks.

Under the capable guidance of Bob Hagemeyer the 1960 Coating Conference proved a high light of committee activities. An attendance of 957 far exceeded that of any previous conference of the technical program. From the communiques released, it is apparent that Dick Martinek intends to challenge this record in Buffalo this May.

The foregoing, in conjunction with the reports that precedes, comprise the report for 1960.

JACK E. WILBER, *Chairman*

Converting and Consuming Division

Plastics Committee

Chairman Wesley Stickel called the meeting to order at 2 p.m. in New York, Feb. 20, 1961.

Plastics Committee meeting: chairman, W. N. Stickel, Texon, Inc., vice-chairman, R. W. Loheed, Chas. T. Main, Inc.

The nominating committee reported the selection of R. W. Loheed, vice-chairman of the Plastics Committee, as the new chairman designate. No other nominations were made from the floor and Mr. Loheed was unanimously elected.

The minutes of the previous meeting in October, 1960, at the Paper Plastics Conference, Syracuse, N. Y., were read and accepted.

REPORTS OF TASK FORCE AND SUBCOMMITTEE CHAIRMAN

Committee Assignment No. 537—Permeability of Plastic Films and Treated Papers. V. T. Stannett, chairman. This project has been completed. A TAPPI monograph is being prepared for publication.

C. A. No. 586—Properties of Paper Affecting Adhesion of Resins in Extrusion Coating. J. Thornton, chairman. Chairman J. S. Thornton defined the proposed scope of his subcommittee and submitted same for approval on the floor. A motion was made by Mr. Arbit and seconded by Mr. Willis to accept the scope of work defined by the subcommittee chairman and to turn over Project 537 to the subcommittee for disposition. The subcommittee meets the following day, February 21, and will submit their report.

C. A. No. 784—Resin Identification and Determination. R. L. Savage, chairman. Sources of commercially coated paper were requested and made available for round-robin testing to Chairman R. L. Savage.

C. A. No. 785—Internal Bond Testing. Fritz Rosenthal, chairman. A straight line correlation was obtained after determining an unknown variable (load scale attenuation) Instron tester. Previous runs will be repeated under standardized procedures after consultation with Instron. This work will be eventually published in *Tappi*.

C. A. No. 803—Catalogue Paper—Plastics Combination. R. W. Loheed, chairman. A steering committee has been formed and provided material to this subcommittee for cataloging purposes. This is intended to be a continuing project which will require the support of all of the members of the Plastics Committee. Contributions were solicited.

C. A. No. 879—16th Plastics Paper Conference. Dr. Howells of The Industry of Paper Chemistry has agreed to chairman this year's conference. Mr. Loheed requested contributions from all members of the Plastics Committee.

NEW BUSINESS

A recommendation has been made to change the name of the Converting and Consuming Division of the Synthetics Division. The proposed scope of the Synthetics Division would be as follows:

Encompass the use of synthetic materials in part or in whole in papermaking and converting operations. Under this Synthetic Division the Plastics Committee would develop areas of specific interest, which if developed to a sufficient degree, would then be pursued by members of a subcommittee such as the newly formed extrusion coating subcommittee under J. Thornton.

A discussion was held regarding the possible cataloging of all members of the Plastics Committee to determine areas of mutual interest and to allow each member to actively participate. Mr. Loheed agreed to undertake such a procedure.

H. A. Arbit, *Acting Secretary*

Wet Strength and Interfiber Bonding Committee

The agenda and decisions taken at the annual national meeting of the Wet Strength and Interfiber Bonding Committee which was held Feb. 21, 1961, in New York were as follows:

Committee Reorganization. C. S. (Scotty) Maxwell assumed the chairmanship of the committee following the moving up of Ken Britt to the Converting and Consumer Division vice-chairmanship. M. L. Cushing was appointed to the position of secretary.

Joint Session with Plastics Committee. It was agreed that the Wet Strength and Interfiber Bonding Committee would provide a series of papers as part of the October 9–11 Plastics-Paper Conference at French Lick, Ind.

A review of Research Proposals or suggestions for areas of research under the jurisdiction of the committee was conducted. It was decided to proceed with write-up for submission before April 1 of a proposal from the State College of Forestry at Syracuse University on the Mechanism of Wet-Strength Development with Polyethylene-imine, and, secondly, to refine the areas of research proposal for future consideration on location, identification, and effects of natural (and synthetic) resins on or in papermaking fibers.

A subcommittee comprising A. C. Schmalz, chairman, D. S. Most, J. W. Swanson, and H. L. Winslow was appointed to work on the polyethylene-imine project write-up.

After having decided that the polyethylene-imine project should have first priority a voting to select the second priority project, which was the above-mentioned resin location study, it was found that the third place choice would go to the suggested work in the area of retention of polysaccharide wet-end additives, fourth place to proposed studies on rheology of wet-strength papers in various solvents. It was evident that little interest remained concerning a suggestion for work on mechanism of filler retention, with some feeling that any work here should belong under some other committee's jurisdiction.

Program for National TAPPI 1962 Meeting. It was decided that tentatively the committee would solicit papers and plan to sponsor a session at the 1962 annual TAPPI Meeting.

Revision of Wet-Strength Monograph. While no decision was taken there was a discussion and general agreement that it would be worth while to consider undertaking a revision of TAPPI Monograph Series No. 13, Wet Strength in Paper and Paperboard.

New Members. The following are new members of the committee: Alex Pociluyko, Scott Paper Co.; Grant K. Rauscher, International Paper Co.; Richard B. Valley, Eastman Kodak, Rochester, N. Y.

M. L. Cushing, *Secretary*

Synthetic Fiber Committee

The first meeting of the Synthetic Fiber Committee was held during the Annual TAPPI meeting in the Hotel Commodore, New York City, at 2:00 p.m., Feb. 22, 1961. Eight committee members plus 28 interested guests were present.

Synthetic Fibers Committee meeting: chairman, R. A. A. Hentschel, E. I. du Pont de Nemours & Co., secretary, W. J. Bublitz, Minnesota Mining & Mfg. Co.

The objective and scope of the Synthetic Fiber Committee were reviewed by R. A. A. Hentschel, chairman. The objective of this committee is to further the use of man-made fibers in the paper industry. The scope of this committee includes both wet and dry sheet forming processes for nonwoven sheets. The committee is to be made up of representatives of (1) fiber producers, (2) binder producers, (3) sheet manufacturers, and (4) technical institutions. The chairman reviewed the present membership of the committee, shown in the address list of these minutes.

The chairman opened a discussion of possible areas of activity for the Synthetic Fiber Committee. The following suggestions were reviewed as a starting point for the discussion.

1. Development of standard testing methods for products of man-made fibers.
2. Preparation of a monograph on the properties and handling of man-made papermaker's fibers.
3. Sponsorship of a session at TAPPI's Plastics Paper Conference in October, 1961.

In the discussion which followed, it was brought out that quality control tests are needed by the paper companies for the man-made materials and for use on the wet end of the paper machine. It was also brought out that information is needed on the market opportunities of products made from these materials. After some discussion, it was concluded that the accumulation of this market information was outside the scope of this committee. The sponsorship of a fundamental study of the fibrillation properties of synthetic fibers was discussed. It was pointed out that this information is available from the manufacturers of most of these materials and could be included in any monograph on the properties of these materials.

A vote was taken on which project to undertake first, the development of standard test methods or the preparation of a monograph on the properties and handling of man-made papermaker's fibers. The preparation of a monograph carried.

After some discussion, it was decided by vote that the committee should support a panel discussion at the October, 1961, Plastics Paper Conference sponsored by TAPPI. It was also decided that the committee will canvass the paper industry for papers suitable for presentation at the next Annual Meeting of TAPPI in Feburary, 1962.

Subcommittees will be appointed to handle the details of the panel for the October Plastics Paper Conference and to initiate work on preparation of the fibers monograph.

J. T. Martin, *Temporary Secretary*

Corrugated Containers Division

Steering and Advisory Councils

A joint meeting of the Corrugated Containers Steering and Advisory Councils was held at the Commodore Hotel, N. Y., Feb. 20, 1961.

Minutes of the previous meeting of the Steering and Advisory Councils, Oct. 10, 1960, were accepted as written.

Report on February 1961 Technical Program—R. C. Hutcheson reported on the status of the final arrangements for this meeting. Mr. Hutcheson received the sincere thanks of the group for the excellent handling and planning of the meeting.

Report on Fall, 1961, Eleventh Corrugated Containers Conference at San Francisco—H. W. Wilson, general conference chairman, reported that at present they plan one full day on flexographic printing, one-half day on production boxes for field packing, one-half day devoted to subjects submitted by the Engineering Committee, and one full day of tours. The proposed budget for this meeting was submitted. H. T. Scordas was appointed as publicity chairman for the meeting. He is to act as liaison agent between H. O. Teeple and H. W. Wilson. We want to make sure that we get as much publicity as possible to all of the corrugated industries.

Annual Report and Directory for 1961—A deadline of Aug. 30, 1961, for presentation to TAPPI was set.

COMMITTEE REPORTS ON PROGRESS AND PLANS

Production—Loren Ashwood. Mr. Ashwood said that they now have 19 active members. They have committees on adhesive consumption, supervisory training course, production control figures, and errors. They are also discussing the possibility of setting up projects to investigate plant procedures and matching sets, counts, and standardization of terminology. Other projects in various stages of investigation are evaluation plans for supervisors and standardization of waste figures.

Committee Assignment 786—The supervisory training committee has prepared 11 training programs, and it was decided to arrange for appropriate distribution through TAPPI channels.

Process and Quality Control—Harry Dunholter. Mr. Dunholter reported that they had 25 active members. Project 762, Corrugating Defects and Remedy Manual, is in final stages of assembly. This should be ready for submittal and/or a possible TAPPI paper shortly.

Committee Assignment 754 has been altered somewhat and has now been changed to a survey of statistical techniques used by box plants.

Committee Assignment 752—Survey of Plant Quality Control Methods, is being reactivated. Much of the original information was lost during member's change in job responsibilities.

Committee Assignment 761—Evaluation of Pin Adhesion, has been completed. A finished report will be made to the Process and Quality Control members only.

New projects include investigation of top-bottom compression and a survey of tolerances and allowances for automatic packaging machinery and their correlation with production.

Industrial Engineering—R. S. Owen. Mr. Owen reported that they are still in their organizational and planning stages. They now have 17 members. Discussion of means and methods to be used in increasing participation was made. They have discussed as possible projects: (1) standardization of industrial engineering terms for corrugated industry; (2) the measure of productivity by machine center; (3) rating films for corrugated operation (leveling factor); and (4) manuals for in-plant training. All agreed that this was a very ambitious program and certainly is needed by our industry.

Corrugated Containers Steering Advisory Council meeting: chairman, J. J. Koenig, Gaylord Container Corp., vice-chairman, R. W. Buttery, Bathurst Containers, secretary, K. R. Martin, Olin Mathieson Chemical Corp.

Raw Materials—A. L. Magnuson reporting for G. R. Wilmer. Mr. Magnuson reported that the liner and medium committee has been investigating moisture variables and how they effect plant operation. They have also run some tests to determine the coefficient of friction as it affects operation. The subcommittee on adhesions is pretty well along on a manual which will include equipment, handling techniques, testing procedures, etc.

Engineering—A. Richardson. Mr. Richardson reported that they have 30 members. Twelve members are manufacturers of corrugating equipment and 18 are members of the corrugating industry. While their membership at the present time is filled other people are invited as observers. They have three meetings a year. Their work on the takeup ratio has been progressing well but are encountering a great many variables which still need further investigation. On the project to design a standard box plant, they started with a known product mix and volume and then designed a plant starting with site selection, building, equipment selection, etc.

Plans for February, 1962, Meeting—T. W. Carroll, technical program chairman. At Mr. Carroll's request, he asked that a replacement be named. This appointment was left open. Jack Comly, Joe Simpson, and A. J. Dennanberg were suggested.

Plans for Twelfth Corrugated Containers Fall Conference (Committee Assignment 882) at Boston, Oct. 23–26, 1962—P. J. Cox general chairman. Mr. Cox reported that the technical chairman will be Al Schwartz. Harry Dunholter was selected as one moderator with the others to be selected at a later date. It was suggested that we have one day of committee meetings, one day of technical papers, and one day of plant tours. However, this was left open. It was discussed that quite possibly one-half day should be assigned to the Process and Quality Control Committee, one-half day to the Raw Materials Committee with the other half day open for later developments. Subjects discussed were automation, preprinted liner, hot melt adhesive, top-bottom compression, interpretation of V-board specifications, design of containers for automatic case sealing, and the corrugating remedy and defect manual.

Plans for Thirteenth Corrugated Containers Fall Conference (Committee Assignment 886) at Detroit, Oct. 22–25, 1963—Fred Atwood, general conference chairman. Loren Ashwood was appointed technical program chairman.

Plans for the Fourteenth (Committee Assignment 3000) Fifteenth and Sixteenth Corrugated Containers Conferences. The dates and hotels have been confirmed for the 1964 Dallas

and 1966 Los Angeles meetings. The 1965 meeting to be held in Atlanta is still in negotiations.

Proposed New Committee—R. L. Jenk. It was agreed that we should hold this over until the fall conference which will permit Mr. Jenk to make his presentation.

Manual for Guidance of Technical Divisions and Committees. M. A. Burnston, TAPPI, reviewed TAPPI's work in this area.

New Numbering System—M. A. Burnston. The new numbering system was explained. Each division will have a block of numbers assigned to it. The Corrugated Containers Division is assigned block series 3000. It was explained that to have a project assigned a TAPPI number it is necessary for the request to be signed by committee chairman and routed to the division chairman for approval. TAPPI will then assign a number for distribution to all interested parties. Each Committee Chairman will be kept informed on all projects for all of the Corrugated Containers Division. We have also been asked to use project numbers in all correspondence.

General. There was considerable discussion on meeting planning and methods of improving the flexibility and the introduction of current ideas into the TAPPI program.

KEDWICK R. MARTIN, *Secretary*

Corrugated Containers Industrial Engineering Committee

The meeting was held Feb. 21, 1961, in New York.

Final Preparation for Industrial Engineering Talks. Chairman Owen asked T. W. Carroll, session moderator, to review preparations for the committee's participation in the Corrugated Containers Session II.

All arrangements had been completed and the speakers were reminded of the author's breakfast on Wednesday morning.

Industrial Engineering Committee—Production Committee have 1962 Program in New York. Chairman Owen reviewed the February, 1962, meeting plans. Jack Comly of the Production Committee will serve as Technical Program Committee chairman; A. J. Dannenberg and C. B. Lawler will be session moderators.

Projects. Chairman Owen, pointing out that projects are the primary purpose of Committees, led a discussion on the selection of projects for the I. E. Committee.

Three projects were tentatively picked:

1. Standardization of terms, with definitions.
2. Manuals for in-plant supervisor training on subjects within the realm and scope of the committee's work—such as production standards, waste reduction, and materials handling. This will supplement the work already underway by the Production Committee.
3. Measures of productivity.

One other possible project, Rating Films for Corrugated Operations, was discussed and tabled since it was the general consensus of opinion that this would be too controversial and involved to be worked on at present.

The officers and past chairmen met in a short meeting after the regular committee meeting and assigned chairmen to each project:

Definition of Terms, George Austin
Manuals for Supervisor Training, R. J. Buckley
Measures of Productivity, L. C. Wightman

A meeting of project chairmen and committee officers was tentatively scheduled for April 1961 in Chicago to get project work underway.

Other Items. F. H. Cloud resigned as vice-chairman due to new restrictions on his available time. H. A. Buckley was appointed by Chairman Owen as the new vice-chairman. Mr. Cloud will continue as a member of the committee.

Harold H. Kroll, who has been reassigned by his company, resigned from the committee.

Corrugated Containers Industrial Engineering Committee meeting: chairman, R. S. Owen, R. S. Owen & Co.; vice-chairman, F. H. Cloud, Packaging Corp. of America; secretary, J. Sprague, Green Bay Box Co.

Chairman Owen asked N. H. McDonald of Owens-Illinois, C. L. Prowdzik of St. Regis, C. H. Colton of Continental Can, and Karl F. Gabhardt of Owens-Illinois to consider committee membership.

W. C. Kline and T. W. Carroll each showed films of operations in some of their companys' plants: Mr. Kline showing a printer-slotter setup and partition slotter operations at their Anderson, Ind., plant, and Mr. Carroll showing slitting and partition slotting scenes from one of the Owens-Illinois plants. Both sets of films were excellent and the group thoroughly enjoyed seeing them. Mr. Kline described the basic equipment costs and techniques required or recommended for making such films.

Chairman Owen's film on die cutting was not shown because of lack of time.

L. C. Wightman asked if anyone was using quality as a factor in their incentive payment. Time cut the discussion short but this will be discussed thoroughly in the next meeting.

J. C. SPRAGUE, *Secretary*

Corrugated Container Process and Quality Control Committee

The meeting was called to order at 9:10 a.m. on Feb. 20, 1961, in Parlor C of the Commodore Hotel in New York City by Chairman Harry Dunholter. The meeting was begun by the reading of the minutes of the last meeting in Toronto on Oct. 10, 1960, by the secretary.

Percy Cox, general chairman of the Twelfth Corrugating Conference in Boston Oct. 23–26, 1962, then asked the committee to provide speakers for one-half a day of this conference. He emphasized the need to give brief interesting talks from the technical papers and then, during the discussion period, bring out such technical details as are controversial. He mentioned the use of preprinted technical papers which fits in well with this idea. The committee agreed with this procedure.

Harry Dunholter, tentative moderator, then emphasized the need for speakers to talk about automation, putting numbers on values, etc. He suggested asking the chairman of Production Committee for help. Also mentioned were preprinted liners and hot melt adhesives. Mr. Rubenstein brought up the question of how to pinpoint the variables that need to be controlled.

Henry Nelson had suggested to Mr. Dunholter a desirable subject would be a top-to-bottom compression study to correlate with the column test.

Corrugated Containers Process Quality and Control Committee meeting: chairman, H. E. Dunholter, Owens-Illinois; vice-chairman, S. L. Goodrich, General Box Co.; secretary, P. J. Cox, Consolidated Water Power & Paper Co.

Another suggestion was the interpretation of V-board specifications by a competent government authority. Dr. Killinger helped write the original JAN-P-180 Specifications. Tom Muldoon of Fibre Box Association was also suggested.

Ked Martin suggested a discussion of the relationship of quality control to the customer to assist the customer to differentiate between what he needs and what he wants.

There was considerable discussion about the tolerance required on corrugated boxes to be run through automatic case-sealing machinery.

Harry Dunholter, subcommittee chairman for Project 762, the Corrugating Defect and Remedy Manual, reported on their project. He thanked the people working with him, George Lecky, H. Seibel, Ned Varner, Alan Schwartz, and Ked Martin. They will reproduce the manual with pictures and send a copy to each member of the committee as soon as possible. Anyone having pictures of corrugating defects is requested to send them in.

On Project 754, Manual of Simple Statistical Techniques, Harry Dunholter said Mr. Nelson apologized for lack of time to devote to it. Mr. Rubenstein, who was going to take charge, said that at a meeting in Toronto last fall he suggested that we should find out what is being done first. He indicated that a survey would be valuable and we would need professional help to complete the job. He will get started to determine what statistical techniques are now being used, with the help of Mr. Timmer, Mr. Corcoran, Mr. Siddiqim, and Mr. Cox.

On Project 752, Ned Varner indicated that he needs more help. W. B. Lincoln, Jr., Don Long, and Mr. Rubenstein indicated that they will help him.

On Project 761, Harry Dunholter said that he will ask Frank Albert for a final report on the pin adhesion project. Frank Albert dropped in on the committee meeting in person and asked to resign because his new duties are much different in nature.

Suggestions for new projects included "Organized Training of Quality Control Men in Plants." Ed Carpenter agreed to head up a project on corrugated containers for automatic packaging equipment. He will investigate aspects of box construction such as allowances and how close will scores break. Additional help will be appointed as necessary.

Donald Macaulay, a vistior from The Rochester Institute of Technology, was asked to make a few remarks. He indicated that quality is obtained by the boss by various methods, some good and some bad. Just because statistics are not used, it does not mean that quality control is not used.

PERCY J. COX, *Secretary*

Engineering Division

Engineering Economics Committee

Mr. Sargent introduced the new members and announced the appointment of George Davis of Bowaters as vice-chairman of the committee.

Mr. Blood read the minutes of the October, 1960, meeting in Jacksonville.

Mr. Sargent asked for the reports of the project chairmen. Only two members who had been assigned projects in Jacksonville were present.

Ray Marsh of Walter Kidde Engineers will continue his work on Committee Assignment No. 929, "Bibliography of Articles on Economics." Mr. Marsh plans to publish his listings in *Tappi* in the near future.

David Taylor of Time, Inc., is currently formulating his approach to his project, "Economics of Research and Development Planning and Evaluation."

George Wachter of American Can Corp. who is project chairman of the project, "Outline of Cost Reduction Potential in Paper Mills," was unable to attend the meeting. Mr. Sargent stated that Mr. Machter will have a questionnaire ready for distribution to the mills within the next month.

Joseph Voci of Arthur D. Little, Inc., project chairman for the project, "Outlines of Simple Solutions for Cost Estimating," was unable to attend the meeting. No report was given.

Robert Polk of Appleton Machine Co., project chairman of Committee Assignment No. 928, "Engineering Cost Analysis" was unable to attend. No report was given.

Mr. Sargent announced the appointment of Thomas O'Hare as chairman of project organization. At this point the letters and form concerning committee correspondence and reporting procedure were distributed to the members. Mr. O'Hare stated that the centralization and consolidation of reporting procedure and correspondence will serve as an effective feedback system.

Mr. Sargent made the following assignments to new members:

George Gordon of Diamond National was assigned the responsibility for Data Sheets.
Herbert Kranich of Johns-Manville was assigned the responsibility of committee publicity.
Karl Dornich of S. D. Warren was given the responsibility of assisting Mr. Polk with Project No. 928, "Engineering Cost Analysis."

Mr. Davis discussed his tentative program for the October, 1961, Engineering Conference at Washington, D. C. Mr. Davis plans to obtain a group of three papers by DuPont entitled "Determining the Best Facilities for a Company's Need." These papers will deal with the engineer's, the client's, and the field personnel's job in constructing new facilities. In addition, Mr. Davis will have Bowater's personnel present a paper entitled "Economic Consideration and Design of Plant Structures."

Mr. Marsh discussed the 47th Annual Meeting of TAPPI next February. It was decided to present a paper on the economics of batch versus continuous pulping. Mr. Marsh and Mr. Blood will assist John Crocker of Stone & Webster Engineering Co. in the formulation of this paper.

JOHN BLOOD, JR., *Secretary*

Mechanical Engineering Committee

The Mechanical Engineering Committee met for luncheon Monday, Feb. 20, 1961, at 12:30 p.m. in Tudor No. 3 room of the Hotel Commodore, New York City. Chairman J. S. Mudgett presided. Fifteen members and two guests were present.

Chairman Mudgett called the meeting to order at 1:15 p.m., with appropriate remarks welcoming all members and

Mechanical Engineering Committee meeting: chairman, J. S. Mudgett, Strathmore Paper Co.; secretary, R. P. Finney, St. Regis Paper Co.

guests present. The minutes of the October meeting of the committee at Jacksonville were accepted as presented. The first order of business was outlining the program to be presented by the Mechanical Engineering Committee at the 1961 Engineering Conference to be held at the Shorman Hotel, Washington, D.C., on Oct. 15–19, 1961. The subjects are as follows:

1. Mill experience with first suction press installations.
2. Roll-less-Flo-Vac.
3. Comparison of suction roll materials (stainless and bronze.)
4. Mechanical features of continuous pulping systems. Four short papers discussing the pros and cons of the systems.

The possible papers that may be given at this conference are:

1. Skewed roll calender stack.
2. Mechanical considerations for plastic wire installations.

W. G. Printz reported that one subject: "Suction Roll Application" will be available for the 1962 meeting.

C. E. Hill reported on Data Sheets in progress. He stated that in the near future, at least three Data Sheets will be published. R. A. Jordan is working on the Data Sheet "Velocity in Vacuum Piping" and reports that this work should be completed in the very near future. It was discussed and agreed that a Data Sheet should be undertaken to cover vacuum pulp selection for the paper mill. Mr. Mudgett reviewed briefly the work being done by TAPPI Headquarters in setting up a supervisor of technical information to handle all Data Sheets from the eight divisions of TAPPI, compile same and prepare for publication. With this new position being created, the standard operating procedure for development and distribution of technical information sheets has been rearranged considerably.

The Finishing Room Subcommittee has been a nonproducer and considerable discussion from the floor was involved, with recommendations made that this committee needs personnel to stimulate definite interest. Chairman Mudgett stated that he would be glad to contact a number of companies that make finishing room equipment and see what interest can be stimulated.

The next order of business was discussion of the next interim meeting. Two companies have invited this committee for a meeting at their locations, they being—Beloit Iron Works, Beloit, Wis., and St. Regis Paper Co., East Pepperell, Mass. A vote was taken for the desires of those present, the outcome being St. Regis Paper Co., East Pepperell, Mass. If all goes well, this meeting will take place in the latter part of April. Chairman Mudgett should have data available on the Finishing Department Subcommittee at this time.

Chairman Mudgett read a letter from J. Cundelan, written to S. Anderson, chairman of the Electrical Engineering Committee of TAPPI, regarding any projects, whether presently in progress, or anticipated, for the evaluation of service factors for the selection of gears. After considerable floor discussion on this item, Mr. Goldsmith introduced George Plant of Dominion Engineering Co. Ltd., who was a visitor at this meeting, for his thoughts on the subject. Mr. Plant stated that his company is a member of both the American Gear Manufacturers Assoc. and TAPPI and that there is a fair amount of confusion in what standards to use, especially during the designing and building of a paper machine. Whenever a paper machine is involved, the gear units and gears are selected with the TAPPI standards in mind. However, their company manufactures gears and gear units for other industries and the A.G.M.A. standards are most frequently used. It was brought out that the TAPPI Standards seem adequate for the pulp and paper industry.

It was finally concluded that the paper industry is very fortunate to have these two good sources of data available at its disposal whenever the need arises, and that the Mechanical Engineering Committee will not discuss this problem further. It was unanimously agreed upon that the Electrical Engineering Committee, if the need arises, should pursue this study.

R. P. Finney, *Secretary and Vice-Chairman*

Operations Research Subcommittee

Chairman E. F. Thode announced T. A. Hewson as the new vice-chairman. He will explore the possibility of a joint program with the APPA Operations Research Committee of TAPPI week next year as well as develop a theme and initiate requests for papers for the subcommittee program at the 1962 Engineering Conference. R. W. Roberts, program chairman for the sixteenth Engineering Conference, announced that four papers would be presented on the general theme "Operations Research for Cost Reduction in Industry." Mr. Roberts was appointed publicity chairman for the current year. The committee established plans for abstracting operations research literature of interest to the paper industry and undertook a preliminary study of a project to provide abstracts of computer programs of use to the paper industry.

W. E. Winans, *Secretary*

Operations Research Subcommittee Meeting during 46th Annual Meeting, February, 1961. Chairman, E. F. Thode, Inst. of Paper Chemistry, Appleton, Wis.; vice-chairman, T. A. Hewson, St. Regis Paper Co., New York, N. Y.; secretary, W. E. Winans, International Business Machines Corp., White Plains, N. Y.

Paper and Board Manufacturing Division

Beater Additives Committee

The Beater Additives Committee met in Room F at the Hotel Commodore, New York, on Feb. 21, 1961.

The subject under discussion was the writing of a monograph on the internal sizing of paper.

Mr. Swanson presented a manuscript covering the physcochemical aspects of the sizing process. Previously he had submitted a manuscript covering the surface characteristics of sized paper and this has been distributed to the committee members. Manuscripts have now been received from the following:

R. B. Porter, Wax Sizes
J. W. Swanson, Chemistry & Physics of Sizes (Two Manuscripts)
R. W. Kumler, Testing Paper for Water Resistance

Introduction was received from E. Sutermeister but it was done before complete plans had been laid for the monograph, and it, therefore, needs to be rewritten. Miss R. M. K. Cobb has agreed to do this after the other manuscripts have been presented.

Manuscripts yet to come are as follows:

R. W. Lull, Aluminum Compounds
T. S. Morse, Rosin and Rosin Sizes
E. M. Lorenzini, Bituminous Sizes
R. G. Mispley, Mill Factors Affecting Sizing
R. M. K. Cobb, Introduction—to be written after other manuscripts are in.

There are some brief sections to come in on special synthetic sizes that will be supplied by the manufacturers.

Considerable discussion of the plan of getting the monograph together took place. The procedure being followed is to assign sections to various committee members and as they come in, they are distributed to other members of the committee for criticism. So far very little has been done in the way of criticizing the four manuscripts already received.

It was suggested that this should be pushed. Inasmuch as some of the manuscripts are in rather rough form, it is suggested that the criticism be confined to the subject matter and the arrangement rather than minute detail.

Mr. Masterman advised that a deadline should be set for criticism on the manuscripts at hand and we are, therefore, asking the committee members to express their comments before June 1 of this year. These criticisms will then be compiled and mailed to all members.

Before the meeting took place, the chairman had considerable discussion with Messrs. Swanson and Mispley. Mr. Mispley suggests that Mr. Swanson can give him some assistance in handling some parts of his section. In fact, these two men are going to try to dovetail their two sections together.

In view of this, it may not be possible to completely criticize Mr. Swanson's manuscripts until Mr. Mispley's is received.

All those who have not completed their task were urged to do so as promptly as possible. We should go to print no later than 1962.

T. S. Morse was unable to attend the meeting, but the chairman met with him afterward and he displayed a partially completed manuscript. His work is well along and he hopes to have his manuscript in within a few weeks.

Also, Mr. Lull reports that his manuscript is almost complete.

On account of the geographical distribution of the committee members, it is extremely difficult to hold mid-year meetings. It is, therefore, probable there will be no meeting of the committee until February, 1962, and at that time, we expect to have all manuscripts in.

R. W. Kumler, *Chairman*

Beater Additives Committee meeting: chairman, R. W. Kumler, Waste Paper Utilization Council.

Fourdrinier Committee

The 1961 winter meeting of the Fourdrinier Committee of TAPPI was held during Paper Week in New York at the Commodore Hotel and was called to order at 2:15 p.m. by Chairman Kennedy.

The minutes of the fall meeting were approved as read. Mr. Kennedy then reviewed the half-day program which the committee was sponsoring, and arrangements for the author's breakfast.

Project No. 635—The Problems of High Speed Machine Operation. Mr. Mullins and Mr. Brown have prepared a tabulation of the replies to this questionnaire, which was sent out some time ago. Due to the nature of the questionnaire, it has been very difficult for them to prepare a written summary or draw any conclusions of general validity or interest. The data are interesting to study, but there is no apparent pattern in the replies. A group consisting of Mullins, Brown, Peters, Papesh, and Kennedy was appointed to meet and work out a summary of this material and arrange for the final disposition of this project.

Project No. 734—Dandy Roll Practices. This project has been completed. Messrs. Schad and Hannigan have arranged the data, written the summary, and a special report has been issued to member mills. A panel discussion of the results of this questionnaire has been arranged for presentation during this National TAPPI Meeting. Mr. Hannigan will act as keynote speaker reviewing the results of the questionnaire, and then Mr. Schad will moderate a panel discussion by Messrs. Porter, Mader, Plank, and Sinclair.

The committee commended Schad and Hannigan for the fine job they did on this project, both in quality and in promptness of completion.

Project No. 802—Wet End Process Control. Mr. Hershey reported on the progress that he and Mr. Traxler had made on this project, and presented a rough draft of the proposed special report. This draft covered both a summary discussion of the results for reading by management personnel, and a detailed summary for technical personnel. The draft was discussed and Mr. Hershey will now submit a final draft to Mr. Winchester for publication. The committee discussed this most interesting report, and recommended that it be made the subject of a presentation at next year's National TAPPI Meeting. It is the feeling of the committee that a very good panel presentation could be made.

Project No. 792—Suction Box Covers. The task force assigned to this project met at 11:00 a.m. Monday to discuss the work. Messrs. Fraser, Coats, O'Brien, and Morton

Fourdrinier Committee meeting: chairman, W. H. Kennedy, The Black-Clawson Co.; vice-chairman, R. W. Peters, Eastman Kodak Co.; secretary, R. W. Hisey, S. D. Warren Co.

met, and also listened to a representative of Union Carbide discuss their new suction box material. Mr. O'Brien reported on this meeting and reviewed their progress. They have arranged for Appleton Wire Works to conduct preliminary evaluations of various materials, using end of grain maple as a standard to compare with various hard and soft materials. Samples of many materials of interest have been coded and submitted to Appleton. Some definite preliminary results are expected for our spring meeting. One interesting point which came out in discussion is the difference of opinion as to whether the major portion of wire wear occurs at the wet or dry boxes.

Peters and Kennedy are scheduled to meet with the Fundamental Research Committee to discuss the possibility of a joint project on Curl, as was previously suggested by the joint advisory committee on Printability Research.

The spring meeting will be held May 18, 19, 1961, at West Monroe, La., with possibilities for visits at Olin Mathieson and Crossett Paper Mills. At this meeting we will discuss the question of a symposium on sheet formation.

The nominating committee reported their recommendations for officers of the Fourdrinier Committee for 1-year terms. These would be:

Ralph W. Peters, chairman
Robert W. Hisey, vice-chairman
Judson Hannigan, secretary

ROBERT W. HISEY, *Secretary*

Structural Fibrous Materials Committee

The meeting was called to order by W. H. McPherson at 9:15 a.m., Feb. 22, 1961, in New York, N. Y. Minutes of the 1960 meeting were read and accepted.

Subcommittee reports were presented as follows:

S-1 New Project and Review. No report was available in the absence of Chairman E. J. Reichman.

S-2 Papers and Publications. Chairman E. M. Jenkins reported that five papers were to be presented at that afternoon's session. He urged that thought now be given to next year's presentations. The idea of making next year's papers conform to a central theme possibly covering production problems was presented and evoked general interest. It was also announced that the paper presented last year by E. M. Lorenzini of American Bitumels and Asphalt Co. was now available. Copies can be obtained from E. M. Jenkins.

S-3 Test Board Formation. Chairman R. G. Lacey was absent and no report was available. The chairman was requested to finalize and close out this project. W. A Chilson will forward results obtained at FPL to Chairman Lacey for his information.

S-4 Drainage Time. Chairman E. M. Jenkins reports substantial completion of their project. He proposed a 1-year continuation during which use of a centrifuge will be considered for dewatering. Prints for the drainage time apparatus are available from A. J. Winchester of TAPPI. The apparatus is available through the Laurel Machine & Foundry Co., Laurel, Miss., and Williams Apparatus Co., Watertown, N. Y.

S-7 Racking and Nail Holding. Chairman R. H. Neisel reported the Standards Committee has refused the listing of the proposed racking test as a suggested method as it does not define the test sufficiently due to allowing each manufacturer to specify his own nail type and spacing. He also reported that the appropriation request for funds to complete the racking strength-edge nail resistance correlation had been refused by the Appropriations Committee.

The main committee voted to resubmit the racking test procedure with explanations that comparable results could only be obtained with comparable nail type and spacing and to state that is the intent of the procedure.

The committee also agreed to perform edge nail tests at 0.06 and 2 in. per min. on their own products and submit the results for an overall correlation. R. H. Neisel will circulate the test procedure for discussion. This will provide background data for an edge nail test procedure to be written.

S-8 Light Reflection Measurement. Chairman W. L. Scott was not present. It was recommended that a final report on this project be prepared and the project closed out.

S-9 Consistency Measurement. Chairman A. H. Chamberlain reported the decision to submit the consistency test procedure as a suggested method. He will also prepare a shorter test for routine control purposes and submit it to the membership for discussion.

S-10 Rate of Drying. Chairman L. Eberhardt was not present but had submitted a letter requesting to be excused as chairman. W. M. McNeill reported a research type test to be possible but might not be of general application. He will summarize his survey results for the membership.

S-11 Preparation of Methods. Chairman J. J. Perot was not present. He requested assignment of E. M. Jenkins and R. A. La Cosse as subcommittee members. They were appointed. The subcommittee was asked to circularize the main committee for suggestions as to proper methods for inclusion. The methods may be written up by S-11 or channelled to other subcommittees whose assignments are related to the subject.

Structural Fibrous Materials Committee meeting: chairman, W. H. McPherson, Minnesota & Ontario Paper Co.; secretary, R. H. Neisel, Johns-Manville Research Center

General

A. H. Chamberlain will report results of the questionnaire on sizing to the main committee members.

The committee discussed TAPPI representation on ASTM Committee C-16. No member was found able to assume the duties. The secretary was instructed to determine whether one of the present company members could carry the responsibility and also vote twice. (The vice-chairman of C-16 has stated that to be impossible. He suggested one of the present members be assigned TAPPI liason duties on a nonvoting basis so that SFMC can be kept informed of C-16 activities.)

A letter of appreciation from G. H. Chidester of FPL concerning donation of the drainage time tester has been received and is quoted in part: "We appreciate very much the action which you have taken and assure you that the tester will be used to good advantage in our Pulp and Paper Division."

Elections

The chairman and secretary were unanimously re-elected for a 1-year term.

The resignation of A. H. Chamberlain from the Steering Committee was regretfully accepted due to his impending retirement (in about a year and a half). The chairman appointed R. D. Fels of Donnacona Paper Co. to the position.

R. H. Neisel, *Secretary*

Water Committee

The meeting was called to order by Chairman Baker at 9:30 a.m. Feb. 21, 1961, in Parlor A of the Commodore Hotel.

Copies of the minutes of the last meeting were passed around to the few attendees who had not yet seen them. Two minor corrections were noted, changed, and minutes accepted.

Chairman Baker briefly described the situation of our task group projects (12 total) and the need for completion of the majority. These are so close to final approval and issue that he assigned responsibility for each of them. Most of the Standards are ready for task group review. If no dissenting comments are received in two weeks from date of mailing, the vote will be assumed as affirmative and the Standard will be moved to the standards advisor for final processing. If serious disagreements occur, it will be necessary to return the Standard to the task group for reassessment.

The official authorized projects of the Water Committee are as follows:

No. 638	Proposed Standard for Iron Determination
No. 639	Standard of Definitions and Terms Relating to Water
No. 640	Standard for Turbidity
No. 641	Standard for Solids Determination
No. 642	Standard for B.O.D. Determination
No. 890	Standard for Hardness Determination
No. 899	Standard for Manganese Determination
No. 900	Standard for Color Determination
No. 901	Standard for pH Determination
No. 902	Standard for Alkalinity and Acidity Determination
No. 903	Standard for Flow Measurements
No. 904	Standard for Sampling

All of these projects are in some form of preparation. With possible exception of Manganese, Sampling and Acidity and Alkalinity, rather advanced situation prevails. There was considerable evidence that most could be completed soon.

J. G. Weidman presented a concise, yet complete description of JCUMWE and its functions. There were some questions as to the actual value of participation, whether or not our committee should represent TAPPI, and general concensus was that we need to. It was explained that we can issue standards without JCUMWE endorsement, if it is believed that the Standard fits only the paper industry. In general, however, it was evident that JCUMWE endorsement is desirable.

Water Committee meeting: chairman, R. J. Baker, Wallace & Tiernan, Inc.; vice-chairman, H. M. McFarlane, Abitibi Power & Paper; secretary, S. K. Adkins, National Aluminate Corp.

Chairman Baker announced the following resignations:

R. J. Keating—chairman of Subcommittee II (Program)
J. G. Weidman—JCUMWE representative
O. F. Hutchinson—chairman of Subcommittee V (Industrial Water)
S. K. Adkins—secretary

Chairman Baker asked for volunteers to act as TAPPI representative to JCUMWE, but there was conspicuous lack of response. One problem is the need for the man assuming this job to travel to two meetings per year. As such, it is usually necessary for clearance to be obtained from a company. Chairman Baker asked for anyone having ideas for filling this job to please write him.

Robert Dvorin volunteered to assume the duties of chairman of Subcommittee II (Program). Chairman Baker stated that Hutchinson had already obtained a promise for a 1962 paper.

A discussion of technical sessions ensued with the general conclusion that a $^1/_2$ day session (three papers) was the best arrangement. All believed that papers should reflect actual mill experience. It was also emphatically stated that papers should be obtained early so that we could request Tuesday afternoon session. This helps "compact" the Water Committee activities the first three days of the week, avoid conflict with the National Council for Steam Improvement, and generally encourage attendance to various committee meetings.

J. R. Coursault of Betz Laboratories was announced as the new committee secretary. He was appointed to fill the unexpired term (until Feburary, 1962) of S. K. Adkins. Agreement between incoming and outgoing secretaries was that Adkins would write up minutes of these sessions and then turn all records over to Coursault.

R. E. Bodette was suggested to assume the duties of chairman of Subcommittee V (Industrial Water) but he was not present. Chairman Baker stated that he will get in touch and appoint him if he is agreeable.

Chairman Baker described the idea and procedures of merging various committees of TAPPI that have a major interest in water. A spirited discussion of whether or not the resulting group should be a division or a committee ended with agreement that it would be most effective to have a Water Division with special interest committees. This appeared to be the best way of assuring effective effort on water technology, standards, and technical sessions. J. G. Weidman moved and H. M. McFarlane seconded that Chair-

man Baker write the necessary correspondence to recommend merging the water interested committees into a Water Division. Motion was passed on a voice vote.

Chairman Baker announced the names of the Nominating Commitee that was appointed by the Advisory Subcommittee. They are: E. R. Gamlin, Chairman, R. A. Dando, and G. U. Proctor.

Mr. Gamlin was alerted to the need of reporting the nominations early enough to allow a letter ballot in October, 1961.

Mr. Bodette entered the meeting and Chairman Baker asked him if he would serve as chairman of Subcommittee V (Industrial Water). He accepted the appointment.

SELDEN K. ADKINS, *Secretary*

Pulp Manufacture Division

Alkaline Pulping Committee

The meeting was called to order at 2:00 p.m., Feb. 19, 1961, in New York by Chairman David Wetherhorn. A previously distributed agenda for the meeting was called to the attention of members present. Due to poor flying conditions and the airlines' strike, some members did not arrive in time for the meeting.

Minutes of the Portland (previous meeting) were approved as prepared and distributed.

H. O. Teeple reported on the Portland meeting. Minutes of the meeting were published in the October issue of *Tappi*. The meeting was a financial success with an income of $6873 resulting in a surplus of $219. A good program was presented, attendance was very good, with more wives present than in the past. The ladies' program was excellent. It was a successful meeting.

Chairman Wetherhorn and H. O. Teeple again commended Hugh Wickett and his committee for the fine job they performed in putting on this meeting.

A brief discussion of the 1961 February program brought out that the number of good papers presented required two sessions of three papers each: one session at 2:00 p.m. Monday in the Windsor Terrace Room and the other Thursday morning in the Windsor Court. As Tex Collins, program chairman, could not be present, David Wetherhorn presided at the first session, and Paul West at the second.

Some discussion of the number of papers, the split meeting, and the difference from published announcements followed. Mr. Teeple explained the problems of space and arrangements, as well as the difficulty of being exact several months ahead of the meeting.

A discussion was held on the Fifteenth Alkaline Pulping conference. This meeting is to be held at Houston, Tex., in the Rice Hotel on Nov. 1–3, 1961.

Discussion started with a presentation of a proposed budget submitted by H. O. Teeple and John Parrott for the meeting. A considerable discussion followed concerning past practice of alkaline pulping meetings, and a searching for the proper position for this committee to take on mill visits, hospitality get-togethers, and the proper conduct of our conferences. The need for getting the group together informally, to become acquainted, and to make available a common meeting place, when formal business was not in session, was definitely recognized. The best interests of the industry people and the suppliers were considered. After much discussion, the following policy motions were made to guide the Alkaline Pulping Committee and officers. Mr. Charbonnier moved:

> Be it the policy of the Alkaline Pulping Committee for Houston and the future to establish only paper mills as official mill visits for their conferences. This was seconded by Vernon Woodside and unanimously carried.

John Parrott asked for a general expression on mill visits for Houston. It was the general thinking an attempt should be made to have all mills open to visitors at the time. At least one mill should be available on a scheduled basis. A formal visit to either East Texas or Lufkin to be tentatively set up; and, if enough people did not indicate a desire to visit these mills for a formal tour at registration, the visit be relegated to an informal basis. Diamond Alkali and other companies in the area will be open to those who desire to visit them.

Alkaline Pulping Committee meeting during 46th Annual Meeting, February, 1961. Chairman, D. Wetherhorn, Southern Paperboard Corp., Port Wentworth, Ga.; vice-chairman, P. H. West, Thilmany Pulp & Paper Co., Kaukauna, Wis.; secretary, R. R. Fuller, Gulf States Paper Corp., Tuscaloosa, Ala.

John Parrott moved:

> The Alkaline Pulping Committee recognize the need for an informal conference get-together and suggest as a budgeted meeting item a very modest hospitality hour.

The Alkaline Pulping Committee did not want to be in a position implied or otherwise of pressuring, enticing, or suggesting that suppliers support or vie for the presentation of a hospitality hour. If a supplier or suppliers wished to offer support of a hospitality hour for the second night, the committee will carefully consider it; but such an hour will be guided by the degree of elaborateness of the first night get-together. Mr. Charbonnier seconded and the motion carried unanimously.

The action taken will require a revision of the proposed meeting budget.

Chairman Wetherhorn is to convey our appreciation of the Diamond Alkali offer and to acquaint them with the committee's method of approach to the situation. Local Chairman Parrott is to cover the same area with the local people.

Vice-Chairman Paul West discussed the program for this meeting and read a letter from Tex Collins stressing the need for papers. Everett Cann, program chairman of the Neutral Sulfite Committee, was present representing his committee for their part of the program. Discussion of the program favored a panel on outside chip storage in the south featuring actual practice.

Another suggested panel was to feature the various systems of screening stock in black liquor prior to washing. Paul West covered some of the other possibilities and the subject was left with Paul West to contact Tex Collins and advise him of the possibilities discussed.

The Sixteenth Annual Pulping Conference, Hotel De Soto, Savannah, Ga., Oct. 31 to Nov. 2, 1962. H. O. Teeple reported on arrangements to date and a short discussion followed. Dates and place are fixed, and generally arrangements are in good shape.

Consideration was given to the Seventeenth Annual Pulping

Conference. H. O. Teeple reported on progress toward finding a place to hold this meeting.

On motion by Charbonnier the meeting was set in Greenbay, Wis. The meeting is to be held preferably the last week in September; and secondly, the second week in October.

Monograph On Chemical Recovery. In the absence of J. W. Johnson, due to transportation difficulties, Dr. Roy Whitney reported for the committee and, also, on his work to date in organizing the monograph.

Dr. Whitney covered the work of the committee and the guidance he had received from it. He then explained in detail the approach to the monograph outline. The monograph proper is to take the liquor cycle from the black liquor storage tanks to the white liquor storage tank. Presently this is to be handled in five steps: (1) introduction—probably two chapters—background, need, definitions, and a discussion of black liquor; (2) the concentration of black liquor; (3) the combustion of black liquor; (4) chemical conversion; and (5) plant design and operation, operating problems, and control.

On motion by Bob Fuller amended by Jack Limerick and seconded by Charbonnier it was unanimously voted:

The Alkaline Pulping Committee record its thanks and appreciation for the fine job Dr. Whitney has done on the project. To approve in principle the plan for producing the monograph, and to approve the securing of persons to write the chapters by Dr. Whitney and the committee.

Dr. Whitney indicated a report of the complete plan with authors should be ready for the Houston meeting.

Chairman Wetherhorn thanked Dr. Whitney and complimented him on a job well done.

Chairman Wetherhorn discussed the work of the Testing unable to be present. The white and green liquor analytical procedures are published. Activity test method is submitted.

A prepared request for funds to support research on the long standing project to develop a method for accurately determining black liquor solids was again turned down. There was a brief discussion of this matter. John McGovern, as division chairman, explained the action on the project and the studies of the board on the whole problem of research grants.

Chairman Wetherhorn called attention to the fine, hard work Dick Kessler put in on this committee. The progress made was largely due to Kessler's efforts. On motion by Ed Thode, seconded by Paul West, and carried unanimously: that Dick Kessler be suggested for a special recognition citation for his work on this subcommittee.

Ed Thode reported for the subcommittee on Nonconventional Pulping Methods. Henry Crandall of the subcommittee was also present and entered into the discussion. Thode pointed out some of the problems of this survey, and some possible conflicts of interest. A brief discussion of the overlapping of committee interests followed. The report then went on to outline what the committee expected to cover. This committee expects to have two papers ready for the Houston meeting: (1) a summary and discussion of nonconventional pulping, and (2) a comparison of chemical analyses, and other properties of alkaline pulps with other methods, particularly the modified sulfites.

Peter Borlew reported for the subcommittee on the chemistry of the sulfate cook and digester corrosion. Borlew recommended this subcommittee be discontinued. On motion by Paul West, seconded by John Parrott, it was voted to discontinue this subcommittee.

Chairman Wetherhorn brought up the problem of Alkaline Pulping Committee size, and the need for additional membership. It was generally agreed that the committee should be expanded. Fuller reported on a survey of present membership. This matter was discussed at some length, and past practice reviewed. On motion by Charbonnier, seconded by Borlew, the following was adopted: The Alkaline Pulping Committee would be expanded by and the discretion of the chairman. Past ground rules would be checked, but would not be binding.

Chairman Wetherhorn indicated his intention to obtain definite commitments from management for prospective members to take part in the activities and to circularize present membership before adding to the Committee. He reported the resignation of Jay Goss and Dan Adams had been regretfully accepted. E. E. Archibald and R. M. Graff were added.

Definite steps will be taken to enlarge the committee.

Chairman Wetherhorn appointed Messrs. Charbonnier, Running, and Parrott to recommend officers for the alkaline Pulping Committee's coming year at the Houston meeting.

Chemical Products Committee

The Chemical Products Committee met in Room 1004 of the Commodore Hotel at 2:00 p.m. on Monday, Feb. 20, 1961, with an attendance of 16 including ten committee members.

In consideration for contributions to the 1962 Annual TAPPI Meeting, it was the general feeling of the committee that it should attempt to get together a program for a symposium or round-table discussion stressing the area of tall oil and soap skimmings. The efforts of the committee will be directed toward one technical session on tall oil including batch and continuous methods and another session on improvements in soap skimmings collection. However, there will be no intent to limit the technical program to these subjects and any contributions on subjects within the areas of the scope of the committee will be included in the program. Sydney Coppick of Scott Paper Co. was elected general chairman for the 1962 Chemical Products Sessions.

The next business on the agenda pertained to the possibilities for the committee to engage in the preparation of monographs. I. A. Pearl, chairman of the subcommittee on monographs, presented the following report:

Report of Monograph Subcommittee

On the basis of the subcommittee conference through individual personal conversations, telephone conversations, and correspondence the following report is submitted in the form of suggestions for consideration and action by the Chemical Products Committee at its annual meeting in New York on Feb. 20, 1961.

Monographs on appropriate subjects should be prepared by the Chemical Products Committee, and each individual monograph should be limited to one specialized field. Suggested subject matters for individual monographs include whole tall oil manufacturing, tall oil and turpentine, lignin and vanillin, acetic and formic acids, furfural, alcohol and yeast, etc.

For each monograph there should be constituted a separate nonstanding subcommittee which would have the responsibility to appoint the authors and the editor to coordinate the work and to see the monograph published, after which time its existence terminates. As in accordance with standard TAPPI practice, it will receive a TAPPI committee assignment number and will report to the parent committee.

Inasmuch as TAPPI expects the editors and the contributors to do the work without renumeration, an attempt should be made to distribute the work load of subcommittee membership, editorship and authorship for the separate monographs.

Irwin A. Pearl, *Chairman,* Monograph Subcommittee

Following Dr. Pearl's report, considerable discussion of the subject ensued which culminated in Joe McCarthy's motion that, "Each individual monograph should be limited to one specialized field," as recommended by the subcommittee. The motion was seconded and carried.

In discussions regarding the various specialized fields of interest, it was the feeling of the committee that such subjects within its scope as bark extractives, lignin products, etc., did not present very acute problems. However, the necessities of the operating and technical man concerned with crude tall oil production and soap skimmings collection warranted a monograph on these subjects.

Chemical Products Committee meeting: chairman, P. B. Borlew, Celulosa de Chihuahua S.A.; vice-chairman, W. M. Hearon, Crown Zellerbach Corp.; secretary, S. Coppick, Scott Paper Co.

In view of the presence of a representative from the Pulp Chemicals Association, it was suggested that a closer cooperation with this association was desirable.

These discussions resulted in a motion by Edward Nunn that, "Many thanks were due to the subcommittee for their efforts and valuable recommendations." This motion was seconded and carried unanimously.

The general feeling was that to avoid delay until the next meeting, the Committee should appoint a task force for the following purpose: "To investigate the feasibility of a monograph on tall oil, soap skimmings and related subjects with or without the inclusion of turpentine."

The following members were elected to constitute this task force: C. E. Tyler, D. E. Campbell, P. E. Shick, R. E. Kelly, P. B. Borlew—chairman.

The suggested scope of the proposed monograph would include such topics as: historical introduction, equipment, technical know-how, analytical procedures, specifications and markets, but would not include refining of tall oil since this area would fall beyond the obligations of TAPPI.

It was further agreed that the Technical Group of the Pulp Chemicals Assocition would report back to the committee on their feelings as to what extent they could cooperate in the proposed undertaking.

Under the subject of other business, it was announced that the vice-chairman, W. M. Hearon, regretted that business pressures would not permit his continued participation as an officer of the committee. However, he will continue as a member. The chairman nominated Paul Wiley as vice-chairman of the Chemical Products Committee in addition to his duties as chairman of the Lignin Subcommittee.

New members elected to the committee were:

P. E. Shick, Owens-Illinois Glass Co. (Extractives Subcommittee)
R. E. Kelly, Hercules Powder Co. (Extractives Subcommittee)
D. E. Campbell, Pulp Chemicals Assoc. (Extractives Subcommittee)
E. H. Nunn, Crown Zellerbach (Extractives and Carbohydrate Subcommittees)

SYDNEY COPPICK, *Secretary*

Report of the Committee Chairman

In April, 1958, Arthur Pollak who had successfully guided the activities of this committee for many years resigned as chairman.

Ward Harrison, then president of TAPPI, appointed Peter B. Borlew as the new chairman.

A reorganization of the committee took place at the Annual Meeting in New York on Feb. 23, 1959, thereby the Advisory and the Pacific Regional Subcommittees abolished, its member bodies absorbed into the parent committee and three standing subcommittees established. The subcommittees each comprise a part of the scope of the committee activities: (1) the Extractives Subcommittee to cover soap skimmings, tall oil, turpentine, and other wood extractives, (2) the Lignin Subcommittee and (3) the Carbohydrates Subcommittee which among others covers such items as the manufacturing of acetic and formic acids and furfural from spent liquors.

At the same time the scope of the activities of the committee was redefined to read:

"The processes of manufacturing, refining, utilizing and testing the chemical products of pulping such as turpentine, wood and bark extractives, soap skimmings, tall oil, lignin, dimethyl sulfide, carbohydrates, acetic and formic acids, furfural, and other constituents and derivatives of spent pulping liquors."

It was further arranged that in future every member of the parent committee is to hold a membership in at least one of the subcommittees.

After a lapse of several years the committee also sponsored a technical session at the meeting in February, 1959. Three papers were presented in the field of tall oil and extractives.

Subsequently the committee held a meeting during the Annual National Meeting in February, 1960, at which in the absence of P. B. Borlew the vice-chairman, W. M. Hearon, presided. Among others it was decided to investigate the feasibility of a monograph covering one or the other subject within the scope of activities of the committee. I. A. Pearl was appointed chairman of a subcommittee to report the findings at the next Annual Committee Meeting.

The committee again sponsored a technical session at the 1960 Annual Meeting presenting one paper on turpentine and two papers on the utilization of spent liquors.

At the Annual Meeting in February, 1961, the committee will sponsor two technical sessions, on February 21, presenting a total of seven papers, six on lignin and one paper on the extraction of acetic and formic acids from neutral sulfite spent liquors.

PETER B. BORLEW, *Chairman*

Dissolving Pulp Committee

Minutes of the meeting at Hotel Commodore, New York City, on Monday, Feb. 20, 1961, at 2:00 p.m.

ELECTION OF OFFICERS

The present officers, subject to formal approval, were re-elected for one more term in 1961, namely;

Merle A. Heath, chairman
Edward J. Howard, vice-chairman
Mark Plunguian, secretary

It was decided that after this term of office, future officers would be selected by a system of succession, wherever possible, whereby the vice-chairman would succeed to the chairmanship and the secretary to the vice-chairmanship. The new terms of office will be limited to 2 years.

TAPPI RESEARCH GRANT

A research project on "The Mechanism of Swelling of Cellulose in Different Media" sponsored by the Dissolving Pulp Committee has been awarded TAPPI Research Grant No. 183. The project director is Bengt G. Ranby. The work will be carried out at the State University College of Forestry, Syracuse, N. Y., by Yuichiro Sumi of the Kokusaku Pulp Industry, Ltd., Tokyo, Japan. Dr. Sumi has been given one year's leave of absence. He will arrive in this country in time to start work on April 1, 1961.

Dr. Ranby explained that for the first time a method had been worked out for determining directly the accessibility of the different hydroxyl groups in cellulose by exchanging with deuterium and following the exchange by infrared spectros-

Dissolving Pulp Committee meeting during 46th Annual Meeting, February, 1961. Chairman, M. A. Heath, Buckeye Cellulose Corp., Memphis, Tenn.; vice-chairman, E. J. Howard, Industrial Cellulose Res., Hawkesbury, Ont., Canada; secretary, M. Plunguian, Hercules Powder Co., Wilmington, Del.

copy. This method will be reported on at the April ACS meeting at St. Louis. The method will be applied to thin sections of never-dried wood, both before and after delignification and removal of hemicellulose. Swelling agents will be studied, as well as organic solvents, such as dimethyl sulfoxide, dimethyl formamide, urea, thiourea, and those with other strongly polar groups. The effects on accessibility of drying under different conditions and of reswelling will be determined.

The first report will be submitted after about three months. By that time, it will also be determined whether the Dissolving Pulp Committee would ask for an extension of the Research Project for another year.

The chairman appointed the following subcommittee to follow this work: Schur, Howard, Cruz, and Durso.

Program for Future Meetings

The possibility was discussed of getting comprehensive papers for future meetings on such subjects as the "Future of Cellulose in Relation to Synthetic Products." It was felt that much information along these lines must be available in the different organizations and that they may be willing to release this information. Such papers would be useful not only in assessing the present state of industrial cellulose chemistry, but in stimulating further research work, i.e., not only what has been done, but what can be done and what should be done in new areas in cellulose chemistry to maintain and increase the use of cellulose products.

The chairman will explore the possibility of obtaining such papers for the next TAPPI meeting. The members were urged to find out from their own organizations the possibility of releasing such information and to communicate with the chairman as early as possible.

It was brought out that the Dissolving Pulp Committee was instrumental in bringing Dr. Hunger from Prof. Jayme's laboratory at Darmstadt, Germany, to present a most worth-while paper and movie on fiber structure at last year's meeting. The financial support for this project was obtained partly from TAPPI headquarters and by private contributions from chemical companies. It was suggested that our members keep in mind the possibility of again bringing some outstanding individual to report on a worthwhile study at a future meeting. If such individual needed support for traveling expenses, this could again be obtained by private contributions.

Mark Plunguian, *Secretary*

Mechanical Pulping Committee

As directed by the chairman, Mr. Parsons, the secretary, read the minutes of the last meeting of Dec. 8, 1960. Upon motion which was carried, the minutes were accepted as read.

C.A. No. 680—*A Survey of Groundwood Mill Process Instrumentation*—J. K. Kirpatrick, chairman. Keith Kirpatrick reported that the forms and questionnaires were completed. These were submitted to the members previous to this meeting for comments and criticisms. There were no changes from the original so now it has been referred to TAPPI headquarters for reproduction and mailing. It was decided that the questionnaire be mailed to all mechanical pulp producing mills. Keith requested that there be a prompt response so that the results could be compiled and submitted at the next committee meeting, probably in June.

C.A. No. 932—*Annotated Bibliography for Year*—Gilbert Godin, Chairman. This project was closed out as had been determined by committee action. It will be reinstated as a new project and will be assigned a new project number by the chairman, again as decided by the committee. Keith Kirpatrick moved and S. R. Parsons seconded a motion that the bibliography be published as a TAPPI special report; this was not carried and considerable discussion followed as to the form of publication. It was proposed that it might be suitable as monographic publication every five years. The motion was shelved and Gil Godin was directed to discuss it with TAPPI.

C.A. No. 793—*Fourth International Mechanical Pulping Conference, 1961.* W. H. de Montmorency, general chairman of the conference, was present and reported that the keynote speaker had been contacted and that his reply was awaited. He further reported that a meeting had been held in Montreal, January 27, at which the most important phases in connection with the conference activities had been settled.

S. R. Parsons, general program chairman, had mailed a tentative program to committee members prior to this meeting. It was generally agreed that the program was very good and that it would be most interesting to the industry.

Karl Pingrey reported that he had received details regarding chip groundwood from another source (Continental Can).

C.A. No. 925—*Better Methods of Mechanical Pulp Evaluation*—A. A. Yankowski, Chairman. No report, as the chairman was not present. Mr. Parsons appointed William McPherson to serve with Mr. Yankowski on this committee.

Reports of Subcommittees

1. Grinder Development. J. K. Kirpatrick was asked by the chairman to write a résumé of grinder developments so that the secretary may include it in the minutes. These had not yet reached the secretary so will be incorporated in the minutes of the next meeting.

2. Mechanical Pulping by Other Means than Grinding on Pulpstones. Karl Pingrey will report on the Bersano method and others.

New Project Suggestions

T. F. LaHaise suggests "an accurate means of measuring output of grinders," as a suitable project. Mr. Parsons appointed a subcommittee for this project composed of Messrs. James Griffin, chairman, with Christian Anker and Keith Kirpatrick serving with him. Mr. LaHaise will apply for project number from TAPPI.

N. F. Robertson will submit a report on the Roberts or ring-type grinders.

J. K. Kirpatrick suggested a study of "the effect of shower pressure on the stone face"—its effect on production rate, etc. This project was shelved for the time being.

J. K. Kirpatrick suggested a "study of abrasive versus

Mechanical Pulping Committee meeting: chairman, S. R. Parsons, Consolidated Water Power & Paper Co.; vice-chairman, T. F. LaHaise, Jr., Ryegate Paper Co.; secretary, J. H. Perry, Norton Co.

steel plates for refining groundwood rejects." Mr. Parsons appointed Keith Kirpatrick chairman of the subcommittee. T. F. LaHaise will apply for a project number.

Membership

As requested by the chairman, below is an outline of the duties of our officers as decided by the committee on Feb. 19, 1957, dated March 8, 1957.

Chairman—arranging programs, preparation of agenda and general supervision including direct contact with TAPPI and other committee chairmen with overall responsibility for committee success.

First Vice-Chairman—Recruitment of committee personnel, organization and development of research projects.

Second Vice-Chairman—Responsibility of intercommittee projects such as monographs, questionnaires, etc.

Liaison Officer—The liaison officer who is the immediate past chairman conducts liaison with the Canadian Technical Section Mechanical Pulping Committee and other pulping committees and such foreign groups as may be working independently or in connection with TAPPI on mechanical pulping.

New Committee Officers

As provided in the by-laws of the committee which are quoted above, S. R. Parsons became liaison officer, T. F. LaHaise who was first vice-chairman became chairman-designate and Joseph Blinka who was second vice-chairman now is first vice-chairman. The committee by ballot elected Karl Pingrey to the office of second vice-chairman. J. H. Perry was again elected to fill the post of secretary.

Mr. Parsons, retiring chairman, graciously thanked the committee for their cooperation through his term of office and cited the fact that a great deal had been accomplished during the year. He then turned the chair over to Mr. LaHaise, chairman-designate with sincere good wishes for a successful term. The committee as a whole voiced the same sentiments.

Mr. LaHaise complimented Mr. Parsons for a job well done and then took up the matter of selection of time and place of the next meeting. It was proposed that the next meeting be held at a mill location. He will make arrangements to do this. When this is decided, the chairman will notify the members of the committee.

J. H. Perry, *Secretary*

Pulp Purification Committee

The meeting was opened at 9:05 a.m. Feb. 20, 1961, in New York.

Minutes of the June 13, 1960, Committee Meeting

The minutes of the previous meeting were accepted by voice vote.

Membership Changes

The resignations of Don MacLaurin and Jim Wethern were regretfully announced. No new members have been received. The committee is still looking for representation from West Coast pulp mills.

Suggestions for Future Committee Work

Chairman Kraft reported that some 20 to 25 letters had been received which were complimentary of the Chicago meeting last June, some of which contained useful suggestions for future committee projects. Included in the suggestions were:

1. Study of bleaching technology with a view toward reducing high cost of present bleaching procedures. Reduction in number of stages and extension of efforts in high density bleaching were two approaches cited as promising.
2. A study of the relationship of pulp bleaching techniques to physical properties of the fibers was recommended.
3. Another pulp bleaching conference in 1962 or 1963.

The committee felt that (1) was an excellent suggestion but too general in nature. Number 2 was also a worthy field for study. The committee was in general agreement that a tentative date for the next pulp bleaching conference should be agreed upon; 1962 was felt to be too soon. It was felt that the conference could be worked out in 1963. The committee voted by show of hands to consider a 1963 conference leaving final decision on the matter to be made at the February, 1962, committee meeting.

Preparations for the Current Pulp Purification Sessions

Chairman Kraft announced the plans for the two pulp purification sessions held on Feb. 22, 1961. Assignments for assistance by committee members at the sessions were made. Details of the sessions including time tables were presented and discussed.

Report on Liaison Work with Corrosion Committee

Lance Crosby reported on activities of the subcommittee appointed to establish liaison with the Corrosion Committee.

The subcommittee had a satisfactory meeting with the Corrosion Committee in Chicago at the time of the First Pulp Purification Conference. This meeting was reported in detail in *Tappi* (43, No. 9; 160–162A). A later meeting at the Engineering Conference in Jacksonville last fall was not nearly so productive due to inadequate representation from the Pulp Purification Committee.

There are two current projects of the Corrosion Committee which are of interest to our committee. Project No. 824 "Corrosion Resistance of Titanium" and No. 839 "Success and Failures in Chlorine Dioxide Manufacturing and Bleach Systems." The Corrosion Committee will appreciate suggestions and comments on these and future projects of mutual interest. These should be sent to Lance Crosby in writing for presentation to the Corrosion Committee.

TAPPI Research Grant No. 154

Howard Rapson reported that the work on this project will be completed in about a week. The task was much larger than was anticipated. Forty-seven written pages plus ten pages of drawings are completed. The final report will amount to 65 pages with five pages of bibliography. It will bring the literature study completely up to date. Dr.

Pulp Purification Committee meeting: chairman, F. Kraft, Marathon Corp.; vice-chairman, R. J. Auchter, Kimberly-Clark Corp.; secretary, L. B. Taylor, Columbia Southern Chemical Corp.

Spinner has prepared a highly condensed, critical review of the literature together with recommendations for future research work. Ferd Kraft and Dick Auchter will review the work on its completion.

The committee discussed means of publishing the report. Suggestions were made that it be published as a separate monograph and that it be incorporated in the Pulp Bleaching Monograph. It was decided to allow the subcommittee on project 154 to decide what recommendations would be made respecting publication.

Monograph on Pulp Bleaching

Howard Rapson reported that all chapters, except one, have been received. Final correlation of various elements of the book will be undertaken as soon as the last chapter is in. Each author will receive his chapter back with instructions for final revision to bring the work up as close as possible to the target date. Publication early in 1962 is still the target.

New Officers

The nominating committee had previously nominated Richard J. Auchter as chairman-designate but the election had been deferred due to the impending National Conference. The name was resubmitted and Chairman Kraft asked for a motion. The motion was made and seconded that nominations be closed and Mr. Auchter named chairman-designate. This was approved by a unanimous vote of the committee members present.

Dick Auchter accepted the nomination. He suggested that, for the future, a vice-chairman should be appointed to establish a line of succession. Howard Rapson agreed with this and further suggested that a chairman of this committee should serve for 2 years. No action was taken on either suggestion.

Research and Development Division

Forest Biology Committee

The fifth business meeting of the Forest Biology Committee was called to order by Chairman Donald D. Stevenson at 9:00 a.m. on Feb. 21, 1961, at TAPPI Headquarters, 360 Lexington Ave., New York, N. Y. Eighteen members of the committee or their representatives, two interested guests, and Dr. Harry Lewis, chairman of the TAPPI Research and Development Division, attended and participated in the meeting.

Following a brief introduction of members and guests, Chairman Stevenson asked that the minutes of the business meeting of Aug. 26, 1960, in Seattle, Wash., be read. These minutes were approved without comment. The following items of business were then taken up:

Review of Forest Biology Conference. In connection with the Forest Biology Conference of August, 1960, in Seattle, Chairman Stevenson mentioned that the conference lost money because of low registration; but he reaffirmed the feeling that the conference was good and valuable, and that another should be planned in the near but indeterminate future. Driver asked about publication of papers that were presented at the conference. Chairman Stevenson replied that these should be available shortly.* Dr. Lewis mentioned possible binding of the reprints of conference papers and suggested consultation with the TAPPI staff about this. Chairman Stevenson is to follow up on this possibility.

Report of Subcommittee 1, on Bibliography. In the absence of Philip Larson, chairman of Subcommittee 1, Chairman Stevenson reviewed briefly the status of the subcommittee and its work. Almost a thousand references have been processed to date for the bibliography, and Larson is hopeful that this job will be completed by early summer.

Besley mentioned the follow-up of his and Larson's discussions at Seattle as to possibilities of using the Oxford decimal classification system for the bibliography. He and Larson have concluded that a changeover to the Oxford decimal system would be impracticable at this stage of the work.

Lewis wondered if an annual supplement to the bibliography could not be made. Wangaard noted that action is needed now if the bibliography is to be brought up to date through 1960. Chairman Stevenson noted the possible desirability of setting up a permanent subcommittee to handle this matter, and Lewis suggested adding to the membership of Subcommittee 1 and changing this membership frequently enough to prevent the work from becoming burdensome. Wakeley suggested overlapping memberships as a basic necessity for a permanent subcommittee with changing personnel.

Lyon asked about the scope of the abstracts being prepared by Subcommittee 1, and wondered if they couldn't be continued on a regular basis by some organization such as the Commonwealth Forestry Bureau, Oxford, England, which might include certain special categories for our use. Besley said that the Oxford people are not particularly interested in this at the moment but may be later. He noted, further, the completeness of the Oxford abstracts, and the possibility of duplication on the part of our Subcommittee 1. Wangaard replied to the effect that Subcommittee 1's bibliography will contain items not found in the Oxford abstracts, and that it should find somewhat readier use.

In connection with continuation of Subcommittee 1, Chairman Stevenson asked for formal action on the part of the parent committee. Mitchell moved that Subcommittee 1 be continued on an active basis, with staggered membership, for the purpose of keeping current the bibliography, and that its membership be left to the discretion of the chairman of the Forest Biology Committee. Wangaard seconded this motion. The motion carried without opposition.

Report of Subcommittee 2, on Tests and Quality Objectives. Philip N. Joranson, chairman of Subcommittee 2, distributed copies of the annual report of his subcommittee, which report noted the completion and publication in the November 1960 issue of *Tappi* of a report on wood properties that influence processing and properties of paper. (Reprints of this report are available from B. K. Mayer, secretary of Subcommittee 2.)

* They appeared in the March, 1961 issue of *Tappi*.

Work is well along on the second major job of Subcommittee 2, namely, to promote improvements for methods of small-scale wood quality evaluations. This job is proceeding stepwise in three phases; survey of existing methods, evaluation of these, and development of additional or improved methods. The first step is being handled by questionnaire, and the second step will be carried out through subgroups appointed by Joranson.

Chairman Stevenson commented appreciatively on the tremendous amount of work being done by Joranson and Subcommittee 2 on its current assignment. Present subcommittee membership consists of Joranson, Driver, Echols, Hiett, Lyon, Mayer, Mitchell, Salvesen, Seidl, Wangaard, Wilder, and Zobel.

In connection with the accomplishments of Subcommittee 2, Chairman Stevenson reviewed additional publication plans for the subcommittee's report on wood properties that influence processing and properties of paper. A popularization of this is to appear in the *Forest Farmer*. Chairman Stevenson is to review this carefully before publication, however Wangaard suggested that announcements of the availability of reprints of the Forest Biology Conference papers, including the report of Subcommittee 2, be made in all technical and popular forestry magazines. Seidl spoke on the point of reaching people outside of TAPPI with news or information on the Forest Biology Committee. In this connection, Chairman Stevenson mentioned that he is to give a paper on Feb. 22, 1961, at the annual meeting of the American Pulpwood Association on the formation and current activities of the TAPPI Forest Biology Committee. Lewis suggested that the Committee prepare a list of all publications, such as the *Forest Farmer, Journal of Forestry, Journal of the Forest Products Research Society*, etc., that might carry news of the Forest Biology Committee; and that this list be made available to the TAPPI staff for routine, intermittent publication releases.

Systems of Characterizing Wood Quality of Existing Forest Stands. At the business meeting in Seattle in August, 1960, a lively discussion on systems of characterizing wood quality of existing forest stands was culminated with the suggestion that the subject be discussed more fully at the February, 1961, meeting of the Committee. Such a discussion, full and fast, did indeed occur.

Chairman Stevenson opened this discussion by quoting from a letter written by Besley outlining his thoughts on the subject. Besley commented further on this letter, noting that a classification of characteristics is needed that can be understood by woods and mill people, and correlated as between woods and mill. According to Besley, a need exists not only for recognizing wood quality characters, but also for expressing these quantitatively as found in the woods and as needed in the mills. Besley recognizes that the subject can't be divorced from genetics or heredity, but he also recognizes the role of environmental factors and their importance.

Mitchell commended on Besley's remarks, agreeing with him and elaborating on the wood quality data being taken in the course of the U. S. Forest Service's Forest Surveys. These data include age, specific gravity, growth rate, fiber length, fibrill angle, total carbohydrates, and perhaps others. Echols remarked that there was some danger of assuming the Forest Survey data to be more accurate for limited areas than it actually is, and a few moments discussion were required to clear up this matter of accuracy or applicability. Besley, commenting on Mitchell's remarks, thought that the Forest Biology Committee should be stimulating by whatever means possible the search for better and best methods of characterizing wood.

By way of refocusing the discussion on the subject at hand, Chairman Stevenson commented that the type of forest management practiced in the Southeast lends itself to strong genetic programs for improvement of both tree and wood characteristics. He noted, however, the natural stand management or utilization being practiced in Canada, the Pacific Northwest, and perhaps other parts of the Continent, and remarked on the necessity of recognizing the internationality of scope of Forest Biology Committee interests.

Following a coffee break, Salvesen commented on the many contradictory situations where wood characteristics highly desirable for one product might be highly undesirable for another. He suggested that foresters should not strive to produce, say, dense wood or long-fibered wood, or wood with some particular or specific character. Mitchell noted that the Forest Products Laboratory must be concerned with the entire range of wood characteristics because of its nonspecific, national responsibility. Besley agreed with Salvesen's and Mitchell's remarks, reiterating that his idea is to develop systems of characterizing what exists in the woods, in order to lay the groundwork for the most efficient utilization of the existing resource. Besley expressed the need not so much for determinations of what characteristics might be best, but rather for yardsticks by which to measure the characteristics that exist.

Wakeley remarked that what the discussion was pointing to was a means of determining specific wood characteristics that correlated with specific paper characteristics. Stevenson carried this idea further by noting that his company, Buckeye Cellulose, produces both dissolving pulp and kraft paper from southern pine; and that Buckeye would be very much interested in knowing which portions of its lands contained wood of character x if character x was more desirable for dissolving pulp than for kraft paper.

Stephens noted that what the committee was talking about was the fundamental descriptive approach to wood characteristics. Once this is done, he said, the next step would be to determine why wood characteristics are different, which would demand the fundamental experimental approach. Stephens spoke at some length and with some fervor on the desirability of having wood characteristics maps, even as we now have soil type maps. Joranson thought that this approach would work best in large procurement areas where single product manufacturing is prevalent, such as the strong-paper province of the south. He wondered if the problem of wood characterization systems mightn't be best approached by manufacturing entities such as the groundwood segment of the Canadian industry. Besley would carry this segmented breakdown even further, to the holdings of single companies, for example.

Seidl noted that there was really no dissension in any of this discussion. What had been said, in many ways, was that the job of classifying wood characteristics should be gone at abstractly and objectively, with those who would use the wood deciding what characteristics might be best for their specific products. Furthering this idea, Mitchell said that the Forest Products Laboratory would like for the Forest Biology Committee to provide some insight as to what characters are meaningful and important, so that the U. S. Forest Service through its Forest Survey and Forest Products Lab could look for and determine how these characteristics occur—not, at the moment, why they occur.

Chairman Stevenson wondered if Subcommittee 2 is not working toward this objective. Besley thought that Subcommittee 2 or some other subcommittee should go a little further than presently contemplated, and determine correlations between characteristics so as to identify and classify these most efficiently. Driver suggested another subcommittee to organize and expedite work in this broad area.

Wakeley suggested using the bibliography being completed by Subcommittee 1 to check on the research that might have been done in this field and that is still needed. Concurring with this suggestion, Wangaard noted that the work of Subcommittee 1 in preparing the bibliography sets the stage for all future work of the Forest Biology Committee.

Seidl suggested that we not appoint another subcommittee

for the moment, pending completion of Subcommittee 1's bibliography and analysis of the accomplishments of Subcommittee 2. Mayer agreed with this approach for the present, in light of the general indecision as to what is wanted, exactly, and the danger of overlap of work. Sensing the general agreement of those present in this approach, Chairman Stevenson summed up this portion of the discussion by declaring that positive action on the subject would await the bibliography and the trend of developments in the work of Subcommittee 2.

Proposals for Future Project Work. Joranson transmitted to the committee a proposal by van Buijtenen that the Forest Biology Committee promote the establishment of some central organization that could carry out uniform, comparable tests of wood characteristics. Such an organization might run standardized measurements of fiber dimensions, yield, pulp characteristics from small wood samples, and pulp characteristics from wood samples large enough to permit beater tests. The specific agency is immaterial; The Institute of Paper Chemistry, N. C. State, Syracuse, or some similar agency might be stimulated by the Forest Biology Committee to undertake such tests for anyone interested in having them made.

Wangaard remarked that the current work of Subcommittee 2 should lead to wood quality tests of the accuracy and uniformity desired, thus making less necessary a central testing lab such as proposed by van Buijtenen. Several others voiced similar opinions. The general feeling of the committee was that no action be taken at the moment on van Buijtenen's suggestion.

Future Technical Sessions. Chairman Stevenson raised the question of Forest Biology technical sessions, such as the Seattle Conference in August, 1960, and the technical meeting during Paper Week of 1959. Salvesen suggested that a technical session be scheduled for Paper Week 1962. Besley wondered about the possibility of a joint session with the American Pulpwood Association in order to draw more foresters to a technical session. The general opinion of the group was that a technical session should be held in 1962, whether independently or in conjunction with some other group. Chairman Stevenson thought that a program committee should be appointed to explore the availability of technical papers, and he will appoint such a committee.

Committee Membership. Chairman Stevenson reviewed the membership setup of the Forest Biology Committee, including the procedure for appointing members. He asked for the feeling of the committee on the present ratio of foresters to pulp and paper representatives, and received no particular strong opinions one way or the other on this matter. Apparently, those present were satisfied with the ratio as is.

Chairman Stevenson noted that the terms of the present committee officers expire in September, 1961, and Joranson recalled that a system of succession from vice-chairman to chairman had been provided for. Whereupon Seidl, present vice-chairman, arose to comment on his somewhat remote geographical location (Seattle), the new responsibilities he has been assigned with his company, and his feeling that someone else could serve as chairman more efficiently. Seidl reaffirmed, however, his interest in the Forest Biology Committee and his intention to continue serving to the limit of his available time. Chairman Stevenson listened sympathetically to Seidl's remarks, and declared that they would be given careful consideration.

J. W. Johnson, *Secretary*

Wood Chemistry Committee

All members of the Wood Chemistry Committee were present in New York on Feb. 20, 1961, to review the progress on its various sponsored projects and to firm up plans for its 1961 Lignin Symposium.

Wood Chemistry Committee meeting: chairman, J. R. Salvesen, Marathon Corp.

Wood Chemistry Committee Sponsored Research

TAPPI Research Grant No. 176—Dr. Kyosti Sarkanen, State University College of Forestry at Syracuse University—*The Mechanism of Bleaching of Lignin in Aqueous Chlorine Dioxide and Chlorite Systems.* Dr. Sarkanen and his students have made considerable progress in understanding the nature of the various reactions which may occur on reaction of lignin with chlorine dioxide and chlorite. The studies basically have involved chlorine dioxide or chlorite oxidation of the model compounds vanillin, vanillyl alcohol, vanillic acid, and similar syringyl compounds as characteristic of the softwood and hardwood lignins. The studies have now progressed beyond identification of intermediate peroxy compounds and quinones to some very neat studies covering the nature of the lactones and acids formed on subsequent ring schism. As there was supporting evidence that similar ring schisms occurred in a high precentage of lignin groupings on similar bleaching treatment, it was felt this project was significant and merited strong support.

TAPPI Research Grant No. 177—Prof. M. L. Wolfrom, Ohio State University—*Preparation and Chemical Properties of Polymer Homologous Oligosaccharides of the Cellulose Series.* Further progress in this study required the development of a more effective analytical tool than simple or reversed phase chromatography. A method of ion-exchange chromatography has now been found to effectively separate the mixture of lactones and glyoxylic acid which were formed on the reaction of cellobiose with sodium hypochlorite at pH 9 followed by acid hydrolysis. This program is being extended to further identify the reaction products, to clarify the nature of the oxidation scheme, and to oxidize other oligosaccharides of the cellulose series to determine reactivity as a function of degree of polymerization and end group reactivity.

Other Grants Approved

The following grants have also been approved and are now under progress:

Grant No. 186—Dr. Renata Marton, State University College of Forestry at Syracuse University—*The Chemical Structure of Colored Bodies in Wood.*

Grant No. 187—Dr. John H. Walkup, Centre College of Kentucky—*Study of Water Extractives of Southern Hardwoods.*

Application for Research Grant

Dr. Conrad Schuerch presented a proposal for a grant to permit continuation of his previous studies on the characterization of dimers from lignin. This study involving reductive stabilization and identification of lignin break down products

during alkaline pulping of wood was interrupted by Dr. Schuerch's tenure as a Guggenheim Memorial Foundation Fellow in England. The previous work has now been reported in a series of papers in TAPPI and it was recommended that support for the extension of this study be requested.

LIGNIN SYMPOSIUM

Lignin—Greater Utilization Through Better Understanding—Edgewater Beach Hotel, Chicago, Ill., Aug. 14–16, 1961. Potential papers for presentation at this lignin symposium, during the week following the Montreal I.U.P.A.C. Symposium, were discussed and a tentative program selected. Dr. Salvesen and Dr. Hearon were commended by the committee for having organized what should be an interesting program on lignin and lignin derived products.

FRANK J. BALL, *Secretary*

Testing Division

Adhesives Testing Committee

The meeting was opened at 9:30 a.m. Feb. 21, 1961. The minutes of the December 14th meeting were amended to make it clear that Bill Neuss is still the editor of the monograph, and Dick Britton is co-author with H. K. Salzberg of the chapter on casein.

In Memory of John Rutzler: Dr. Wakefield spoke of some of his many accomplishments, which included instigation of the Adhesion Sessions at the Gordon Conferences, and of his untimely death last fall. The committee expressed its shock and sorrow, and instructed the secretary to write a note to his widow.

Monograph: Status and comments on each chapter.

Latex: The addition of an exact description of the foaming test will bring this to completion.

Silicates: Completed.

Dextrines: Part 1. Not yet submitted by Goodworth. Sederlund will continue his efforts to reach him.

Part 2. Second draft submitted by Shirley, following recommendations made at the last meeting. This is not a final draft, as more work is being done on literature references, etc.

Part 3. Neuss had several questions on Parts 2 and 3, including the omission of an optical rotation method for determining solubility, the concentration of test samples used in solubility determination, and the source of several pieces of equipment and standards. Sederlund replied that although optical rotation is a standard AOAC method and is used by the Bureau of Standards, it is not generally used in industry, and should be included only as a footnote; the refractometer test for solubility described by Shirley requires solutions of higher solids (10%) than the gravimetric methods (2 to 5%); color standards, and funnels for fluidity tests, are generally made and standardized by the users and have no commercial source; RDS rod (wire-bound rods) are made by R. D. Specialties. Carey and Sederlund discussed the advisability of including detailed descriptions, with diagrams, of test methods which have not yet been agreed upon as Routine Control Methods. It was decided to include those relating to finished adhesives, rather than raw materials, making it clear that they are not considered to be standard methods. It was recommended that the Monograph on Starch and Paper be studied for background material.

Foil Adhesives: Part 1. It was recommended that the paragraph on corrosion be expanded, and should include some faster methods, such as exposure to 85% R. H. for 6 weeks, and elevated temperatures for shorter times. Sederlund requested fuller instructions on how to achieve failure in the glue line rather than in the paper fibers when performing a peel-back test. Kouris would like to have a picture of the applicator system of a laminator.

Adhesives Testing Committee meeting: chairman, R. C. Brown, U. S. Envelope Co.; vice-chairman, H. G. Psyras, Union Paste Co.; secretary, E. Weizenhoffer, Polymer Industries, Inc.

Parts 2 and 3 were discussed in a subcommittee caucus and will be submitted before the next meeting.

Resin Adhesives: Three new members were added to the subcommittee, which held a separate organization meeting, and promised to submit drafts before the next meeting. The new members are Fox, Columbus and Gale; the new chairman—Breslouf.

Compounded Animal Glues: Brown requested that the machines referred to be specified by type rather than by manufacturer's names. There was some criticism of some of the definitions, but it was decided that these will be refined when a general glossary of terms for the entire monograph is written. The chapter will be revised in accordance with comments received from Neuss, and will be ready at the next meeting.

Remoistenable Adhesives: Carey expects to be able to submit draft by the next meeting. He recommends study of the Monograph on Protein and Synthetic Adhesives to all members.

Solvent Adhesives: Psyras is no longer active, but is still expected to complete the work started. If he does not, suggestions will be made for a new assignee.

Tack-Testing: Neuss promises completion by the next meeting. He will include the work done by the committee, and the Bikerman equation for tack.

Pressure-sensitive Adhesives: Next meeting.

Soya-proteins: It was decided to drop this subject, since nothing has been submitted, and there is little general interest in the field.

Hot Melt Adhesives: Neuss will recheck with Yoder, and try to get this subject reassigned to someone with more time to work on it.

Casein: The draft brought in by Britton will be distributed to the whole membership. Based on a quick reading, some suggestions were made, e.g., expansion of the sections on bottle-labeling, compounded products and testing of adhesives, and inclusion of all the references. Neuss expressed the committee's appreciation of the excellence of this paper.

Membership: The membership application form will be revised and distributed to all. Members are requested to fill in and return the new form as soon as possible so that a new Membership List can be prepared.

New Business: The secretary was requested to see that new members receive copies of the Monograph drafts distributed to date, and that old members get copies of some that they have missed.

A shear strength test has been received, and will be distributed for discussion at the next meeting.

Elections: The current slate of officers was nominated and elected to serve for one more year, as follows:

Chairman: Richard C. Brown
Vice-chairman: H. G. Psyras
Secretary: Elizabeth Weizenhoffer

Next Meeting: It was decided to continue to devote full time to completion of the monograph, and to save the speakers for the national meetings and conferences. The next meeting will be held at TAPPI Headquarters in New York on Wednesday, May 3, at 9:30 o'clock.

February 23rd Meeting

Five papers were presented at the Adhesives Testing Session, open to all attending the Annual TAPPI meeting. The session was again attended by an overflow audience, and it is hoped that next year's session may be held in a larger room. The papers presented were:

"The Adhesion Machine," by E. Weizenhoffer and F. C. Campins, Polymer Industries, Inc., Springdale, Conn.
"Effect of Viscosity on the Penetration of Adhesives into Paper," by Miss R. M. Karepetoff Cobb, Lowe Paper Co., Ridgefield, N. J.
"Surface Analysis and Adhesion," W. T. M. Johnson, E. I. du Pont de Nemours & Co., Philadelphia, Pa.
"Factors which Effect the Adhesion of Cellulose Fibers in Paper," by J. W. Swanson, The Institute of Paper Chemistry, Appleton, Wis.
"The Effect of Relative Humidity on the Drying of Adhesives," by George L. Barlow, Monumental Adhesives Co., Inc., Baltimore, Md.

The papers were well received, and there were more questions than time to answer them. Papers will be published in future issues of *Tappi*.

Container Testing Committee

The meeting was called to order at 9:00 a.m. Feb. 21, 1961, by the chairman, A. W. Hoffman.

N. Varner requested to be assigned to the committee and this request was approved by the chairman.

The chairman introduced Mr. Dobbins to the committee. Mr. Dobbins is chairman of the TAPPI Converted Products and Structural Materials Testing Group.

The minutes of the October, 1960, meeting were briefly reviewed by the chairman and were approved as published.

SUBCOMMITTEE REPORTS

Mullen Test Subcommittee (*Assignment 691*). Mr. Knapp, chairman, distributed a tentative method entitled "Test for Bursting Strength of Paperboard and Linerboard," dated Feb. 21, 1961, for review. Mr. Knapp then discussed some of the previous objections which had been raised, mentioned that any grammatical errors had been corrected, cited objections to the use of the term "Cady tester," and indicated previous comments on clamping pressure, and the use of trade names to indicate gages; and reviewed discussion relative to the definition of terms and gage positions.

The committee then reviewed the method with the following modifications agreed upon:

Apparatus. Changes were made in paragraphs 1, 2, 3, and 4. By a show of hands vote paragraph 5 under "Apparatus" was stricken from the draft. The numbering of paragraph 6 was then corrected to 5 and was not further changed.

Calibration of Gage. Because of other modifications, the instruction "(see Note 5)" was changed to read "(see Note 4)".

The phrasing of the instructions applying under the subheading "Test Specimen" and "Clamping Pressure" was changed.

Additional corrections in wording were agreed upon in paragraph 3 under "Procedure," "Reports," "Note 1," "Note 4," and "Reference 2."

Mr. Haynes will contact Mr. Knapp concerning wording of paragraph 1 under "Apparatus." Mr. Knapp will then advise the secretary of the proper wording suggested. The

Container Testing Committee meeting: chairman, A. W. Hoffman, Continental Can Co.; vice-chairman, G. C. Lecky, Kress Box Co.; secretary J. J. Kipnees, Atlantic Gummed Paper

secretary will then arrange to have a corrected copy retyped for final review so that the method can then be promptly prepared for the committee ballot. The members of the Paperboard Testing Committee will be balloted simultaneously.

The progress of the round robin bursting test study, initiated during the February, 1960, meeting, was then discussed. In order to expedite this work, Mr. Knapp agreed to prepare instructions for the round robin testing for all participants.

Flat Crush Subcommittee (*Assignment No. 689*). The chairman of the Flat Crush Subcommittee, H. G. Nelson, was unable to attend; however, he submitted material relating to his assignment along with a covering letter. The material submitted was entitled "Report of TAPPI Flat Crush Study, sponsored by TAPPI Flat-Crush Subcommittee," dated February, 1961. This report essentially reviewed the flat crush studies independently conducted by Container Laboratories and Container Corp. of America. The committee reviewed this report and specifically requested Mr. Maltenfort to provide additional comments. While it was generally agreed that the conclusions arrived at by Mr. Nelson in his report are essentially correct, it was concluded that the wording and presentation required modification so that the subsequent reader would be presented with a combined conclusion which would clearly establish the salient points which both studies developed.

Mr. Hoffman suggested that Mr. Maltenfort and Mr. Nelson confer again to finalize the report which would be ultimately submitted to TAPPI for reproduction. Upon adoption of this report, a TAPPI Flat Crush Test Method will be prepared.

Compression Test Subcommittee (*Assignment No. 690*). Mr. Clark submitted a draft dated Feb. 16, 1961, bearing the designation T 804 m-61 and entitled "Compression Test of Fiberboard Shipping Containers." It will be recalled that this draft is a revision of the existing compression test method and, as such, includes all previously agreed upon noncontroversial editorial changes and improvements. The intention of this most recent draft is to up-date the method. A possible additional future revision will include consideration of controversial areas.

Attention is directed to the initial sentence under the paragraph entitled "Procedure." The TAPPI reference for conditioning will be changed pending the action of the Subcommittee on Conditioning.

Mr. Clark agreed to serve further as chairman of the Compression Test Task Force. Two other members, Mr. Mal-

tenfort and Mr. Varner, were assigned to assist Mr. Clark, and it was further agreed that comments received on the ballot of the proposed date, Feb. 16, 1961, will be sent to Mr. Clark, who will then advise Messrs. Maltenfort and Varner.

Puncture Test Subcommittee (Assignment No. 8009). Mr. Root submitted a document dated Feb. 21, 1961, entitled "Puncture and Stiffness of Paperboard, Corrugated and Solid Fiberboard." This document contained editorial changes to permit the preparation of a TAPPI method based upon the comparable ASTM method designated D 781–59 T.

An itemized list of the editorial changes suggested by Mr. Root was provided along with the suggested draft of the method. For general information purposes Mr. Root called attention to the fact that by subtracting the pointer reading obtained with no specimen in place from the scale reading on scale 1, with the test sample in place, the proper value will be obtained from the specimen without the need for a special scale. This has been found to be 46.5 at 45°.

The method will now be sent to all committee members for balloting.

Drum Test Subcommittee (Assignment No. 717). Messrs. Lincoln and Clark submitted a document dated Feb. 1, 1961, bearing the designation T 800 m-61 and entitled "Drum Test for Fiberboard Shipping Containers." This document represents a suggested TAPPI method based upon the review of the comparable ASTM method bearing the designation D 782–60 T. Mr. Clark mentioned that there are only two significant changes in the method. The previously recorded speed requirement of $1^5/_6$ r.p.m. was changed to $2 \pm {}^1/_6$ r.p.m. to satisfy more nearly the capabilities of existing equipment. The method is also pointed more toward the testing of corrugated and solid fiberboard boxes even to the extent of indicating, under Procedure A, traditional methods for reporting corrugated shipping container damages, i.e., first 1 in. cut, first 6 in. cut, etc. In conclusion, Mr. Clark stressed that the method emphasized the wide variability encountered in the results of drum tests.

This method will also be prepared for ballot.

Drop Test Subcommittee (Assignment No. 718). Mr. Root submitted another draft document dated Feb. 21, 1961, entitled "Drop Test for Fibreboard Shipping Containers" which had been prepared by A. D. Wolvin. This document is a proposed TAPPI method based on a review of ASTM drop test methods and contains appropriate modifications and editorial changes. A listing of corrections and changes was appended to the suggested method which is now ready for balloting. Once again attention is directed to the heading on page 3 of the draft entitled "Conditioning" (Paragraph 4). It will be remembered that TAPPI Standard T 402 m does not apply to containerboard and will be changed when the appropriate specification is prepared.

Conditioning Subcommittee (Assignment No. to be provided). Mr. Seibel reported on his review of ASTM methods relating to conditioning. He recommended that the committee accept the ASTM method with appropriate modifications. Mr. Seibel agreed to provide a new document which will take into consideration the ASTM method and will revise and broaden the current TAPPI method to include fiberboard boxes and components. The document will be presented to the secretary for reproduction and subsequent action.

Definition of Terms Subcommittee (Assignment No. 716). Mr. Lecky presented a compilation consisting of a definition of terms which will be reproduced for distribution to all members. This material is not for balloting but is for review purposes only and is to be returned to Mr. Lecky along with appropriate comments at the earliest convenience. This material is dated 2/21/61 and bears the designation "Tentative Definitions of Terms Relating to Shipping Containers."

OTHER ACTIVITIES

Mr. Hoffman reviewed recent communications from TAPPI requesting our group to review methods for other than corrugated and solid fiberboard shipping containers. After a discussion of this matter it was then moved that the committee confine its activities to corrugated and solid fiberboard containers and component materials. The motion was voted upon and approved by the committee.

Mr. Bachelder presented a verbal report outlining the activities of the "Liner and Medium Subcommittees of the Corrugated Containers Raw Materials Committee." These groups had met a day earlier at the Commodore and Mr. Bachelder, representing our committee, was in attendance. After hearing Mr. Bachelder's comments, it was concurred that no formal Container Testing Committee action was required at this time.

Mr. Cadden submitted his report concerning drop test methods for bags. However, in view of the committee's decision to confine its activities to corrugated and solid fiberboard containers, it was decided to forward Mr. Cadden's report for further reassignment within the division.

A motion was introduced by Mr. Clark, seconded from the floor, and unanimously approved to recommend continuation of current slate of committee officers for an additional 1 year period. Messrs. Hoffman, Lecky, and Kipnees agreed to serve

All subcommittee chairmen are instructed to inform the chairman and secretary of the status of the balloting on their particular assignment not later than one month after due date of ballot.

The officers commended the committee members for their excellent contributions toward the progress of the groups activities.

The next meeting of the Container Testing Committee will be held in conjunction with the fall 1961 Corrugated Containers Conference in San Francisco on Sept. 6–8, 1961. These are revised dates for this conference and a particular session date for our committee will be selected subsequently.

JEROME J. KIPNEES, *Secretary*

Fillers and Pigments Testing Committee

The meeting was called to order Feb. 21, 1961, in New York by chairman Bill Willets at 9:00 a.m. with 13 members and visitors present. The minutes of the previous meeting in Grand Rapids, Mich., on Sept. 27, 1960, were accepted as issued.

The status of projects assigned to committee members follows:

The following methods under Projects 699–701–702 and 704 (Sampling) were submitted to TAPPI Headquarters as approved for submission to the Standards Committee. We expect the committee to approve methods with minor if any changes.

No. 699 Analysis of Calcium Carbonate—George Hall
No. 701 Analysis of Diatomaceous Earth—Herbert Kranich
No. 702 Analysis of Synthetic Silicate Pigments—Nathan Millman
No. 704 Correlation of Test Methods for Various Fillers and Pigments—Sampling—William Kreiling.

Other active projects follow:

No. 700. *Analysis of Talc*—R. S. Lamarr. Returns on the letter ballots on proposed method disclosed numerous comments and suggested changes. It was decided that the comments and changes be considered by the author of the method in drafting a revision of this method. The secretary of the committee will forward the returned ballots to R. S. Lamarr.

No. 704. *Correlation of Test Methods for Various Fillers and Pigments—Moisture*—William Kreiling. Method submitted to letter ballot but not fully approved by committee. Main objection was that the sample suggested for diatomaceous silicates was too large. It was decided that a 25-g. sample be required for clay and "for bulky pigments such as the diatomaceous silicates use a sample of approx. 5 g.

No. 704. *Correlation of Test Methods for Various Fillers and Pigments—pH*—William Kreiling. A general pH method to be applied to fillers and pigments to be proposed.

No. 704. *Methods of Slurry Viscosity*—Paul Plante. This method appears to be more complex than when first considered. It was suggested that it be drafted in three parts, (1) maximum solids, (2) optimum dispersing properties and (3) viscosity and that it be submitted as a routine control method before being considered for a standard.

No. 738. *Testing of Colored Pigments*—Harold Brill. In a memo to the committee Harold Brill mentioned that he had planned to convene his group at this TAPPI convention but only a few raw material suppliers sumitted their suggested tests. In hopes of receiving more information from suppliers, a meeting is planned at the 12th Testing Conference—Montreal, Que., Aug. 15–18, 1961.

T 646 m–54. *Brightness of Clay*—C. G. Albert. To be submitted as a Routine Control Method.

Miscellaneous Mention was made that our next meeting would be during the 12th Testing Conference, Montreal, Que., Aug. 15–18, 1961.

Resignation of Chairman—Bill Willets informed the committee that due to the pressures of other committee and society activities he has reluctantly submitted his resignation as chairman of the Fillers and Testing Committee. Ed Brandon, chairman of the TAPPI Testing Division, suggested that the matter be held in abeyance until the next meeting at the 12th Testing Conference.

S. J. Batruk, Jr., *Secretary*
W. R. Willets, *Chairman*

Paper Shipping Sack Testing Committee

The Paper Shipping Sack Testing Committee meeting was held Feb. 20, 1961, in New York.

Election of Vice-Chairman. On motion duly seconded, it was voted that W. L. Shoemaker be elected to serve as vice-chairman of the TAPPI Paper Shipping Sack Testing Committee.

Project No. 608. Procedure for Wet Tensile Testing of Wet-strength Shipping Sack Papers (1956). Subcommittee responsible for this project include, W. L. Shoemaker, chairman, G. P. Heller, and R. P. Kessler.

W. L. Shoemaker said that once the dry tensile testing procedure is finalized, all that needs to be done in order to adopt it for wet tensile testing is to decide the procedures for: (1) soaking, (2) blotting, and (3) reporting.

Chairman Taylor advised that minutes of Paper Shipping Sack Testing Committee Meeting, Feb. 22, 1960, recorded the fact that the committee was in accord with the Feb. 10, 1960, new proposed draft of TAPPI Standard T 404, a procedure for Tensile Breaking Strength of Paper and Paperboard, except that for precise work the test shall be completed in 20 ± 3 sec. since a simple correlation can be set up between results obtained at the specified speed and those obtained at faster testing speeds.

Mr. Taylor said the new proposed TAPPI Standard T 404 should be used for dry as well as wet tensile testing of shipping sack papers, but that this leaves the committee with the problem of developing a method of preparing samples for wet tensile testing of wet-strength shipping sack paper.

T. W. Lashof agreed to refer this problem to the TAPPI Paper Testing Committee; that the TAPPI Paper Shipping Sack Testing Committee would table this subject until it learned what the TAPPI Paper Testing Committee's recommendations would be for preparation of wet samples for wet tensile testing.

Project No. 769. Tensile Energy Absorption of Shipping Sack Paper (1958). Project to develop a suggested method for Tensile Energy Absorption of Paper is under control of the following subcommittee: H. S. Welsh, chairman, K. A. Arnold, M. L. Taylor, and D. M. Yost.

Paper Shipping Sack Testing Committee meeting: chairman, M. L. Taylor, Union Bag-Camp Paper Corp.; secretary, F. Pocta, Paper Shipping Sack Manufacturers Association

Hewitt S. Welsh presented his report to the TAPPI Paper Shipping Sack Testing Committee.

There was discussion concerning the inadequacy of TAPPI Standard T 402 m for conditioning of samples to be tested for tensile energy absorption.

T. W. Lashof advised that in the second round robin there were included test samples of glassine and long-fibered kraft, in addition to extensible kraft samples; that results of the second round robin showed, in some instances, considerable variability.

Mr. Lashof said they were planning to recheck wide differences to determine their cause.

Consensus was that the procedure recommended by Project No. 769 Committee be considered a referee method; that in addition there be developed a time saving, less precise, routine control method to be referenced in the recommended tensile energy absorption testing method.

H. S. Welsh advised that his committee would submit such a method for measuring tensile energy absorption for consideration by the Routine Control Methods Committee, to be referenced in the TAPPI suggested method for tensile energy absorption.

It was also suggested that the secretary provide A. J. Winchester with copies of the suggested tensile energy absorption procedure, as well as copies of the recommended Routine Control Method for determining tensile energy absorption, for balloting of the TAPPI Paper Testing Committee and TAPPI Routine Control Committee.

Project No. 770. Measurement of Coefficient of Friction of Shipping Sack Paper (1959). Task Force: R. P. Anderson, chairman, A. R. Ewing, R. P. Kessler, and H. C. Martin.

The following have accepted membership as representatives of other committees:

D. W. Reid (Precision Committee)
R. R. Chase (ASTM Committee D-6, Sub-committee III)
K. A. Arnold (ASTM Committee D-6, Sub-committee III)
R. H. Tompkins (ASTM Committee D-6, Sub-committee III)

Chairman Taylor read the following report by R. P. Anderson of current status of this project:

1. Preliminary draft questionnaire prior to round robin sent D. W. Reid, Precision Committee, March 4, 1960.
2. Reply from D. W. Reid, June 10, after several telephone calls. Sheet on test round robin included but no help.
3. Attended Testing Conference, Grand Rapids, Mich. No subcommittee or PSSMA-TAPPI Committee meetings.
4. My increasing technical service to sales activities under existing business conditions have not permitted proper attention to committee work.

5. The questionnaire will be finalized by the first week in January.

Estimated completion date: February, 1962

Manner of completion:

1. Questionnaire to survey equipment in use, methods of test, willingness to participate in round robin.
2. Conduct round robin program (a) establish correlation of test methods, (b) precision of testing equipment between operators and laboratories, (c) recommend suitable and/or common test, (d) supply basis for TAPPI Suggested Methods.

Due to the fact that R. P. Anderson's existing business commitments will not permit further attention to the development of this project, the secretary was instructed to write to Mr. Anderson, asking for up-to-the-minute review of the committee's work and obtaining from him recommendation for appointment of Project No. 770 Committee chairman who would carry on the work to completion.

Next Meeting. It was generally agreed that the next TAPPI Paper Shipping Sack Testing Committee Meeting be held in conjunction with the TAPPI Testing Conference, Aug. 15–18, 1961, in Montreal, Que.

F. Pocta, *Secretary*

Pulping and Papermaking Chemicals Testing Committee

The Pulping and Paper Making Chemical Test Committee met in New York on Feb. 21, 1961. This is a recently formed committee, composed of representatives of several companies which supply chemicals to the pulp and paper industry. The chairman is Herbert S. Hopkins of Olin Mathieson Chemical Corp., Chemical Div., Baltimore 2, Md. The committee is reviewing TAPPI Standard Methods for a number of chemicals and will develop new test methods where necessary.

The present program calls for revision of testing methods for soda ash, sulfur, enzymes, caustic soda, dyes, formaldehyde and alum. Reports from task forces studying these methods are expected by June 1. K. H. Williams, chairman of the Nonfibrous Testing Group, emphasized the importance of developing standard methods which will be used throughout the world. It is desirable to have as broad as possible a cross section of industry thinking in the selection of testing procedures.

K. H. Williams, chairman of the Nonfibrous Testing Committee, suggested the following methods as most urgently requiring revision:

T 610 m-42, Soda Ash
T 613 m-44, Sodium Hydroxide
T 614 m-44, Alum
T 617 m-44, Lime

The committee members had received copies in January of a number of test methods requiring revision, with requests for selection of methods for review. The following committee members agreed to review methods and submit reports on revisions prior to June 1, 1961:

D. S. Batchelor—T 610 m-42, Soda Ash
P. T. Comiskey—T 616 m-59, Sulfur
D. A. Hughes—T 643 sm-54, Enzymes
H. S. Hopkins—T 613 m-44, Sodium Hydroxide
M. Hayek—T 626 sm-43, Dyestuff
B. L. Carlson and R. W. Lull—T 600 m-45, Formaldehyde
R. W. Lull—T 614 m-44, Alum

The chairmen of the above task forces should request cooperation, if necessary, from organizations in supplying committee members. Members of the paper industry throughout the world will use the test methods and it is to the advantage of all suppliers to cooperate in the development of the methods. It is desirable to have a cross section of industry thinking in this work.

The priority for revision of tests is determined by the dates of last issue of the tests. If the method is 5 years old, it should be reviewed and if it is 10 years old, it must be. H. S. Hopkins will request information from TAPPI Headquarters on all correspondence on old Standards.

Pulping, Papermaking Chemicals Testing Committee meeting: chairman, H. S. Hopkins, Olin Mathieson Chemical Corp.; secretary, M. Hayek, E. I. du Pont de Nemours & Co., Inc.

It is desirable to have a logical format and it would be useful to bring the format into line with ASTM Methods. The committee felt it would be useful to set up a means of checking with ASTM on their methods. H. S. Hopkins will advise the tack force chairmen of ASTM efforts in the areas selected above. He will also supply recommendations on the format for Standards, probably based on the ASTM format.

Task force chairmen should summarize the action taken by their groups for use in the TAPPI history file. They should supply this information to the committee chairman.

Interlaboratory testing might be useful in some cases but a decision on this should be made by the committee on an individual basis. Such testing should be avoided, if possible, because of the time required.

Letters had been sent in January by TAPPI Headquarters to several companies asking that representatives be added to this committee. Affirmative responses had been received from Solvay and Penn Salt.

The chairman had received galley proofs from J. d'A. Clark of the following revised methods:

T 600 m-60, Formaldehyde
T 612 m-60, Soda Ash
T 632 m-60, Sodium Silicate

In his letter of Jan. 20, 1961, to Dr. Clark, the chairman stated his objections to having these published. During the meeting, Dr. Clark discussed the benefits of publication. He pointed out that printing of these methods, which contain only minor corrections of previous methods, does not preclude issuing further revisions in the near future. Mr. Brandon held that since the method for formaldehyde was faulty it should be withdrawn. It was decided that the methods on soda ash and sodium silicate should be published but these methods should be revised as soon as possible.

K. H. Williams urged that at least one man be designated to hold an open committee meeting at the Testing Conference in Montreal, Aug. 15–18, 1961. The chairman will assure that such arrangements are made.

Mason Hayek, *Secretary*

TAPPI-ASTM Technical Committee on Petroleum Wax

The General Committee met as Technical Committee M of ASTM Committee D-2 on Feb. 9, 1961. Chairman Dannenbrink called the meeting to order at 3:30 p.m. in the George Washington Room of the Benjamin Franklin Hotel, Philadelphia, Pa. There were 25 members present or represented. There were 11 section members and visitors present.

The minutes of the Sept. 29, 1960, meeting in Grand Rapids were approved as read.

H. M. Smith, chairman of D-2, delivered a word of welcome to Technical Committee M, which in general meets only biannually with D-2. He expressed appreciation for the recent contributions of the Committee in new methods and method revisions.

The section chairmen made verbal summary reports of their activities. (Written summaries are attached to these minutes.) Section recommendations were acted upon as indicated below.

Section I—Physical Properties—M. V. Hunter, chairman. The following appointments of study group chairmen were annnounced: R. L. Murphey, Tensile Strength; J. E. Turner, Modulus of Rupture; K. G. Arabian, Penetration; and G. A. Weisgerber, Melting Point.

Since last meeting, broadening of the scope of D 1321–60 T Needle Penetration of Petroleum Wax was letter balloted. There were 34 approving, no disapproving and 2 not-voting ballots. The revised scope will read: "The method is applicable to waxes having a penetration of not greater than 250 units."

Section II—Chemical Properties—F. A. Brill, chairman. The following appointments of study group chairmen were announced: L. T. Crews, Stability; D. R. Cushman, Composition; and B. R. Bluestein, Purity.

Motion was made and seconded to make the following editorial changes in D 612-45 Carbonizable Substances by substituting the following figures in the last lines of items (b), (c), and (d), respectively, in paragraph 3: 59.5 mg./ml.; 45.0 mg./ml.; 62.4 mg./ml., thereby rounding off the present figures to conform with U.S.P. XVI and N.F. XI. Motion passed.

Section III—Functional Properties—R. C. Paris, chairman. The following appointments of study group chairmen were announced: J. D. Tench, Odor; W. Y. Winey, Sealing Strength; E. A. Pullen, Friction; and J. Walker, Blocking.

Motion was made and seconded to recommend to D-2 and TAPPI Standards Committee, subject to letter ballot of the General Technical Committee, advancement of a revision of method of test for Odor of Petroleum Wax from ASTM 1957 Proposed and TAPPI T 654 sm-58 (Suggested) to Tentative Standards. Motion passed.

Motion was made and seconded to recommend to D-2 and TAPPI Standards Committee, subject to letter ballot of the General Technical Committee, advancement of method of test for 20° Specular Gloss of Waxed Paper from ASTM 1957 Proposed and TAPPI T 653 sm-58 (Suggested) to Tentative Standards. Motion passed.

Section IV—Nomenclature and Definitions—S. W. Ferris, chairman. By letter ballot since last meeting a vote of approval was obtained—32 approve, 0 disapprove, 4 not voting—to recommend two definitions to the parent committees:

Petroleum Wax—A product separated from petroleum which is solid or semisolid at 77°F. and consists essentially of a mixture of saturated hydrocarbons.

Petrolatum—A petroleum wax of unctuous structure containing substantial amounts of oil.

These will be recommended to D-2 for inclusion in D-288, Terms Relating to Petroleum and in a suitable corresponding TAPPI list of terms.

The section also recommended that efforts be made to change the name of Emergency Standards ES-50 from "Ultraviolet Absorption of Waxes" to "Ultraviolet Absorption of Petroleum Waxes."

F. A. Brill announced that he had been appointed by D-2 Advisory Committee to serve as D-2 representative on ASTM E-18, Sensory Evaluation of Materials and Products. E-18 is concerned with principles of psychophysical testing, instrumental sensory relationships, definitions, nomenclature, recommended practices, etc.

The secretary announced the next meeting of the General Committee and its sections with TAPPI Testing Division for Aug. 16–18, 1961, at Montreal, Que., as decided at Sept. 27, 1960, Advisory Committee meeting.

D. I. Walker, *Secretary*

Summaries of Section Activities

Section I—Physical Properties (Chairman—M. V. Hunter)

The cooperative tensile strength tests using standard wires were completed, and a final report will be issued before the next meeting. The use of such wires as part of the test method calibration procedure was discussed. Some of the advantages of using a constant rate of elongation rather than the current constant rate of load in the tensile strength test were discussed, but no action on this change was planned.

It is probable that the published tensile strength reproducibility value (ASTM D 1320) is too low. Cooperative tests to determine current test precision will be initiated at the next meeting.

Several suggestions have been received on ways to improve the precision or the test for "Melting Point of Petrolatum and Microcrystalline Wax," ASTM D 127. Seventeen laboratories agreed to conduct cooperative tests on four waxes to evaluate these suggestions.

The General Committee has approved to extend the scope of the "Needle Penetration of Petroleum Wax," ASTM D 938, to 250 units. The Section voted to retain the use of tenths of millimeter for specifying the test units rather than to adopt the term decimillimeter proposed at the last meeting.

Section II—Chemical Properties (Chairman—F. A. Brill)

The oxidation test (T 650 sm-55 and ASTM M 55 proposed) and its relationship to the newly letter ballot approved peroxide number test was discussed. After discussion as to need for such a method, it was agreed to conduct a cooperative program based on original procedure of air-blowing a sample at 275°F. in the dark and measuring level of oxidation periodically by the peroxide method.

A general revision of D 721 for improvement of precision at low oil content was deemed advisable. Thirteen laboratories will participate in a program using five different samples, which will be initiated soon. Since water content of the MEK solvent has been observed to affect the results on a microwax sample, the need to specify dry MEK will be evaluated.

Editorial changes in D 612-45 Carbonizable Substances tests were discussed on a basis of providing uniformity to descriptions in the U. S. Pharmacopoeia and National Formulary. (It was also observed that D-2 should consider this in the next revision of the corresponding test—D 565—for white mineral oils.)

Section III—Functional Properties (Chairman—R. C. Paris)

The odor method was thoroughly discussed and several revisions agreed upon. These revisions will be incorporated into the method for action by the General Committee.

Results of tests on the difference in sides of standard paper on seal strength were reported. No significant differences were found in studies by two laboratories. A general discussion of the seal test method was held. Some difference in paper has been found, mainly in the Cobb size test. One laboratory intends to splice several samples together, wax on a commercial wax machine and then evaluate seal strength. This is to be reported to the section prior to the August meeting. The section agreed to conduct another round robin of 11 laboratories.

A discussion of the friction method resulted in agreement that static friction could be separated from kinetic friction.

On this basis it was felt that the method was ready to be written up. Available data will be studied to determine whether it will provide a precision section for the method. If not, the study group members will be asked to run friction tests on samples in the sealing test round robin for additional data. It is hoped that a decision can be reached on this method at the August meeting.

SECTION IV DEFINITION AND NOMENCLATURE (Chairman—S. W. Ferris)

After reporting Technical Committee M agreement on the definitions of petroleum wax and petrolatum developed by the committee, the work of the study group on wax classification for test purposes was discussed. It was at the recommendation of this group that Section IV deferred efforts to define paraffin and microcrystalline waxes and adopted definitions for petroleum wax and petrolatum. Since the September, 1960, meeting the study group reviewed 21 ASTM and/or TAPPI test methods, sent a letter ballot to Section IV members, giving the recommendations of the study group on the changes, in title and text, which they considered appropriate in order to remove references to paraffin and microcrystalline waxes, and substitute petroleum waxes or petroleum waxes including petrolatum. Included in the ballot was the question, for each test, "Can this test be run on any petroleum wax?"

The results of the 16 ballots returned, which reflected good agreement with the recommendations, were summarized, test by test, with active discussion from the floor. Mr. Weisgerber, study group chairman, was instructed to prepare final recommendations on each test, and to submit them, as the recommendations of Section IV, to the appropriate chairmen of Sections I, II, and III, or to Technical Committee M if no Section has jurisdiction over the test in question.

It was recognized that changes in the precision sections may be required when, for example, the scope is extended from paraffin wax to petroleum wax, but that matter will be left to the discretion of the other Section chairmen, or Tech M, as the case may be.

D. I. WALKER, *Secretary*

Advisory Section of the TAPPI-ASTM Technical Committee on Petroleum Wax

A meeting of the Advisory Committee was called to order by Chairman Dannenbrink at 4:20 p.m. on Feb. 9, 1961, in the George Washington Room of the Benjamin Franklin Hotel, Philadelphia, Pa.

The minutes of the meeting of Sept. 29, 1960, were approved as read.

The chairman asked for comment on the workability of the duties and activities of the sections and study groups, as outlined at the previous two meetings. It was agreed that in general they seemed a satisfactory basis for the present Committee agreed on the desirability of trying to get some of the details of study group activities worked out in actual study group meetings in order to facilitate section planning in meeting. An attempt will be made to send out section summaries along with advance agendas.

The chairman agreed to send out a revised statement on assignment of duties.

The secretary was requested to set up a number system for all samples used in round robins, which will be posted to a sheet that will be revised and distributed along with membership lists. It will be the duty of the section chairmen to assign the numbers serially, as indicated below, and advise the secretary at appropriate times on description of the assigned samples:

	Number
Section I	MI-61*-1†; MI-61-2, etc.
Section I	MII-61-1
Section III	MIII-61-1
Section IV	MIV-61-1

* To be changed annually.
† Continue serially indefinitely.

A motion was made and seconded to recommend to Section III the development of a standard Method for Determining Surface Wax. Motion passed.

On further consideration of the possible need for other new tests it was agreed that:

1. Petroleum wax committee should be canvassed for possible interest in a pressure blocking method.
2. Consideration should be given to developing a definition of "scuff" and possibly at least develop a test that could be published as a recommended practice.
3. Action with regard to ES-50 Emergency Method of Test for UV Absorptivity of Waxes be deferred until after the August meeting but that in the meantime inquiry should be made on the activity of RD-IV in its development.
4. No action on a water vapor permeability test seemed warranted at this time.

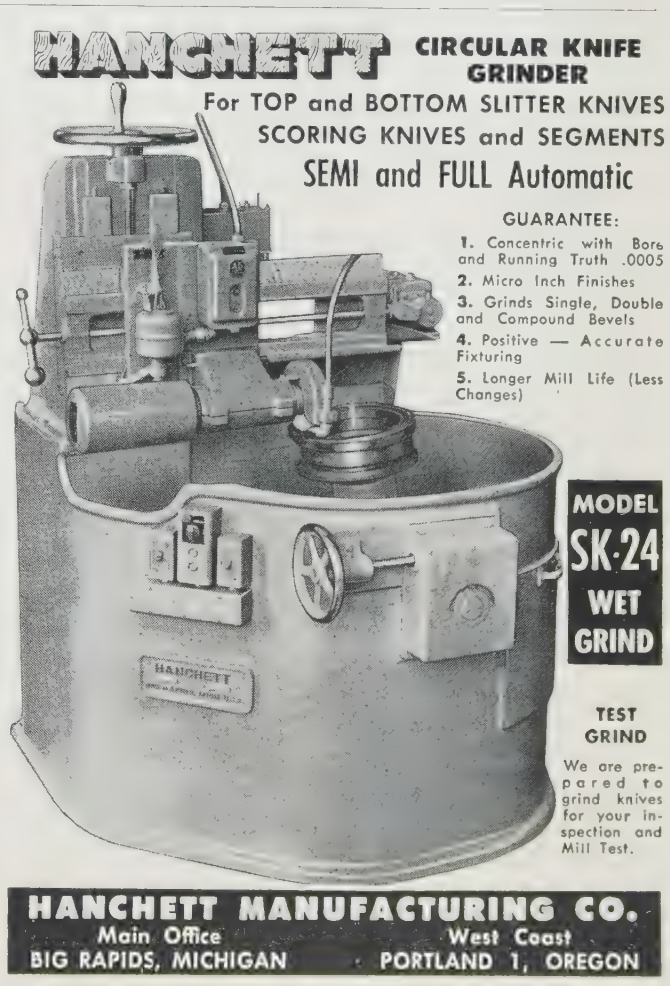
Mr. Ferris announced that Section IV had no immediate program planned other than to summarize recent work for review at the August meeting. Need for future work may be apparent at that time.

D. I. WALKER, *Secretary*

Twelfth Testing Conference TAPPI

Queen Elizabeth Hotel, Montreal, Que.

Aug. 15–18, 1961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RECENT BOOKS

Principles of Unit Operations. By Alan S. Foust, Leonard A. Wenzel, Curtis W. Clump, Louis Maus, and L. Bryce Anderson, Department of Chemical Engineering, Lehigh University, New York, 1960. John Wiley & Sons, Inc. Cloth, 8 1/4 × 11, 579 pages. $15.

The traditional unit-operations concept has been a major factor in the phenomenal success of chemical engineers and chemical engineering in the last fifty years. The authors of this book endeavor to break away from the traditional treatment. They present the unit operations as unified groups of operations stemming from identical fundamentals. The developments are built up from a basic mathematical relation. Two major groups are considered: the stage operations and the rate operations. The stage operations include mass-transfer operations, phase relationships, equilibrium stage calculations and countercurrent multistage operations. The rate operations are exemplified by considerations of molecular and turbulent transport. Application considerations include heat and mass transfer-drying, humidification, evaporation, crystallization, etc.

Warehouse Operations Planning and Management. By Andrew J. Briggs, The May Co. New York, 1960. John Wiley & Sons, Inc. Cloth, 6 × 9, 301 pages. $8.50.

The fourth book in the publisher's Materials Handling and Packaging Series. It is designed to take a warehouse operator through the various stages of layout or modernization in a step-by-step manner. The first step involves knowing the space involved and details of the floor plans. Next is the consideration of pallets, racks, bins, equipment needed, conveyors, operating procedures, management reports, and statistics. It is a well organized book that should be read first, from start to finish, and then reread in terms of existing warehouse problems.

Introduction to Textiles. By Evelyn E. Stout, Cornell University, New York, 1960. John Wiley & Sons, Inc. Cloth, 6 × 9, 363 pages. $8.50.

A testbook prepared by an experienced teacher to meet a need for a new approach to the classification and discussion of textile fibers and fabrics based on the new Textile Fiber Products Identification Act and on performance similarities and differences, particularly of the man-made fibers. People in the paper industry will be most interested in the excellent consideration of the fibers. The synthetic resin, in particular, is impinging on the domain of the paper industry through the trend of combining paper, resins, and textiles. Among the subjects of interest covered are fiber classification and identification, the cellulose fiber, natural protein fibers, thermoplastic and nonthermoplastic fibers, and natural and man-made mineral fibers.

The Physics of Flow Through Porous Media. Revised Ed., by A. E. Scherdegger, Imperial Oil Ltd. New York, 1960. The Macmillan Co. Cloth, 6 × 9, 313 pages. $15.50.

The first edition in 1956 grew out of the need felt by research workers to obtain an idea of the present state of knowledge about the physical principles of hydrodynamics in porous media. In the second edition more attention has been given to deformation of porous media, wettability, and flow through compressible porous media. Some of the topics covered include the fundamental equations of fluid flow, measurement of porosity, hydrostatics in porous media, physical aspects of permeability, the elementary displacement theory, immiscible multiple phase flow, and miscible displacement.

Effective Work Management. By Milon Brown. New York, 1960. The Macmillan Co. Cloth, 5 1/2 × 8 1/4, 246 pages. $5.00.

A basic study written in everyday language of the businessman is directed to the middle-level executive and to young people hoping to become executives. Attention to the human element and finances is minimized and an effort is made to consider the meaning of management, planning and making decisions, executive action, management control, and applying the management processes.

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P528-61. Graduate mechanical engineer with background in maintenance and paper machine design and with some supervisory experience seeks new position in the Pacific North West.

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Miscellaneous

A33-61. INDIA—Paper Technologist with adequate backing seeks technical collaboration for establishment mill for Photographic Base Papers. Financial participation optional.

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Though very well staffed with organic chemists in its other divisions, Client company does not now have a technician with paper background. The new man will be the expert in this area, with a strong voice in the directionalizing of R. & D. activities involving paper and similar substances.

Client company thinks basically in terms of patentable applications and products—and liberally rewards its R. & D. people for development of saleable items. Accordingly, this position offers tempting financial potentials to a creative-minded paper chemist capable of developing commercially feasible applications of chemicals to flat, flexible materials.

Make initial inquiry in duplicate to Mr. George M. Sunday personally, enclosing two pictures and two copies of comprehensive résumé detailing vital statistics; education; social, religious and professional affiliations; and chronological treatment of professional and/or business background and experience. Full confidence guaranteed.

SUNDAY, INC.

Personnel Consultants to Management
Pulp, Paper Packaging & Allied Industries

6 E. Monroe St., Chicago 3 AN 3-1970
(P2002-61)

ENGINEERING DIVISION

Questions and Answers

Good engineering questions are solicited as well as answers or alternate answers to the published questions. Material should be sent to TAPPI Headquarters, marked for the attention of H. O. Teeple. The items contributed will be forwarded to the Question and Answer Committee for processing. If comments are to be contributed, please refer to the question number.

(1-5/61) *Question:* **What is radial thrust and its effect in a centrifugal pump?**

(*1.1-5/61*) *Answer:* Radial thrust results from forces acting on the impeller of a volute pump. If a volute pump is operated at other than its design capacity, a certain unbalance of the hydraulic forces acting radially on the impeller takes place. The maximum unbalance occurs generally at zero capacity and is reduced as rated capacity is approached. This unbalance creates a radial load on the pump shaft and may cause vibration and finally breaking of the shaft.

A means to combat the effect of radial thrust in volute type pumps is the use of a dual volute. With a dual volute the resultant forces at part capacity operation are balanced even though they are not eliminated.

Radial thrust in a single volute pump can be reduced beyond the danger point by installing a by-pass which will permit the pump to always maintain a flow above the minimum requirement for satisfactory operation. The excess flow over the demand can be dumped back to the source from which the pump takes its suction.

(2-/561) *Question:* **How is the approximate combustion air requirement for boiler operation determined?**

(*2.1-3/61*) *Answer:* For a close approximation of combustion air when firing coal, oil, or natural gas, 750 lb. of air per million B.t.u. of fuel fired at no excess air may be used. Excess air may be taken as follows:

Fuel	*Per cent excess air*
Coal	
Pulverized	25
Cyclone	15
Stoker	35
Fuel oil	15
Natural gas	12

As an example, assume a boiler is producing 300,000 lb. per hr. of steam at 875 p.s.i.g. pressure and 900°F. temperature at the superheater outlet with 230°F. feedwater and 87% boiler efficiency. The fuel is pulverized coal:

B.t.u. in fuel

Enthalpy of steam	1452.2
Enthalpy of feedwater	198.2
	1254.0

$$\frac{300{,}000 \times 1254}{87} = 433{,}000{,}000 \text{ B.t.u./hr. in fuel}$$

Combustion air

$433 \times 750 \times 1.25 = 406{,}000$ lb./hr. air

Sanitary Engineering Committee

Increasing public, government, and industry concern over water and air pollution is reflected in actions taken by the Sanitary Engineering Committee when it met in Jacksonville on October 24 at the Fifteenth Engineering Conference. The committee, under Chairman William A. Moggio, decided it will expand its membership to provide broader representation for industry members, and will work toward becoming a clearing house for information on new developments in effluent treatment which will aid the pulp and paper industry.

The committee will continuously review current literature on pollution; will compile and index a yearly bibliography of pertinent articles; and will abstract the more important ones. The bibliography will be published annually in *Tappi*.

The committee is also embarking upon a confidential survey of the industry to determine which men in the various mills are actively engaged in pollution control and would wish to be kept informed of the committee's activities.

A first step in attacking pollution problems at the mill is to find out how much and what kinds of effluents exist. Effluents, however, are frequently discharged through a network of pipes and channels. Measurement of the numerous streams by traditional methods and conventional instruments is expensive and is often not physically feasible or practical. Therefore, the committee, under the direction of its Vice-Chairman Rolland W. Simpson, will accelerate its assembly of material for a Data Sheet on "Unusual Methods of Measuring Flow." It is felt that over the years many simple devices, some of them home-built, have been successfully used. TAPPI members will be asked to share their knowledge of any such methods.

To acquaint TAPPI members and others with concrete evidence of progress in effluent treatment and disposal, the Sanitary Engineering Committee program at the Sixteenth Engineering Conference in Washington next fall will be devoted to case histories of treatment and disposal problems and solutions in the pulp and paper industry. Each paper will describe the problem of one mill and how it was solved. Each solution will illustrate the use of a major type of treatment, featuring the engineering and operational aspects of the installation. Tentatively, the program will conclude with a panel discussion of the merits and drawbacks of the various treatment processes.

The forthcoming program continues the Sanitary Engineering Committee's custom of featuring a single theme for each conference. At Jacksonville three papers were presented on general aspects of water supply in the pulp and paper industry. The paper by R. D. Hoak of Mellon Institute, dealing with water supply and its quantitative relation to waste treatment received nationwide publicity in newspapers and the technical press.

A. E. Dembitz, *Secretary*

Sixteenth

Engineering Conference

Shoreham Hotel, Washington, D. C.

Oct. 15–19, 1961

Chemical Characteristics of the TAPPI Reference Pulp

J. E. TASMAN

The data from 60 laboratories which conducted tests for those properties of particular interest to each on the TAPPI Reference Pulp are presented.

At the TAPPI Testing Conference in Savannah, Ga., September, 1958, the Chemical Methods Committee, together with the Statistics Committee, agreed to set up a program to establish test values for the chemical characteristics of the TAPPI Reference Pulp. This program was intended to provide data which would enable the use of the reference sample as a calibration standard for the chemical testing procedures.

PROCEDURE

Because the Reference Sample is a bleached sulfite pulp, the number of applicable chemical tests was limited to the following:

1. T 203 Alpha Cellulose
2. T 204 Pitch (Ether and Alcohol Extraction)
3. T 206 Cuprammonium Viscosity
4. T 209 Methoxyl Groups in Pulp
5. T 211 Ash
6. T 212 1% NaOH Solubility
7. T 215 Copper Number
8. T 223 Pentosans
9. T 229 Water Soluble Sulfate and Chloride
10. T 230 CED Viscosity
11. T 235 Caustic Solubility

J. E. Tasman, Head, Analytical and Testing Division, Pulp and Paper Research Institute of Canada, Montreal, Que.

In February, 1959, letters were mailed to 510 research and mill laboratories, requesting assistance in performing the required analyses. From this, and a subsequent follow-up letter, 60 laboratories agreed to participate in the program. These replies also indicated that too few laboratories were using T 206, Cuprammonium Viscosity, and T 209, Methoxyl Groups in Pulp, to provide sufficient data on these methods. Because of this, these procedures were not included in the analytical schedule.

Samples were mailed to all participants in April, 1959, together with Data Report Forms, which requested details of each procedure used. On receipt of the completed Data Report Form, each participant was assigned an identifying laboratory number. All analytical data which were received as of Aug. 1, 1959, were used in the program.

INTERLABORATORY RESULTS

Analytical data on the TAPPI Reference Pulp were received from the participants' laboratories by the following procedures:

T 203 m-44 Alpha-cellulose
T 203 m-58 Alpha-cellulose
T 204 m-54 Ether solubility
T 204 m-54 Alcohol solubility
T 211 m-54 Ash
T 212 m-54 1% NaOH Solubility

Table I. The Chemical Characteristics of the TAPPI Reference Pulp

Test	*Procedure*	*No. of labs*	*Sample av.*	*Std. error of average*	*Precision of average* L.C.L.	U.C.L.
Alpha-cellulose	T 203 m-44	10	86.76	0.278	86.20	87.32
Alpha-cellulose	T 203 m-58	15	86.19	0.159	85.88	86.50
Ether solubility	T 204 m-54	27	0.31	0.012	0.28	0.33
Ash	T 211 m-54	39	0.17	0.006	0.158	0.182
1% NaOH Solubility	T 212 m-54	17	8.12	0.346	7.43	8.81
Copper number	T 215 m-50	17	1.89	0.075	1.74	2.04
Pentosans	T 223 m-58	15	2.49	0.118	2.25	2.73
W.S. Chlorides	T 229 m-45	13	0.0296	0.0041	0.021	0.038
Viscosity—ballfall	T 230 m-50	8	102.3	5.60	91.1	113.5
Viscosity—capillary	T 230 m-50	19	14.83	0.210	14.41	15.25
18% NaOH Solubility	T 235 m-58	11	11.60	0.155	11.39	11.81

Table II. Components of Test Data Variation

Test	*Procedure*	*No. of labs*	*Components of variation* Among labs	Within labs	$\frac{\sigma A}{\sigma W}$
Alpha-cellulose	m-44	10	0.872	0.160	5.45
Alpha-cellulose	m-58	15	0.612	0.091	6.73
Ether solubility	m-54	27	0.057	0.030	1.88
Ash	m-54	39	0.038	0.011	3.48
1% NaOH Solubility	m-54	17	1.420	0.181	7.84
Copper number	m-50	17	0.308	0.051	6.02
Pentosans	m-58	15	0.443	0.143	3.10
W.S. Chlorides	m-45	13	0.0147	0.0038	3.91
Viscosity—ballfall	m-50	8	15.8	1.9	8.27
Viscosity—capillary	m-50	19	0.905	0.183	4.94
18% NaOH Solubility	m-58	11	0.496	0.188	2.64

T 215 m-50	Copper number
T 223 m-58	Pentosans
T 229 m-45	Water-soluble sulfate
T 229 m-45	Water-soluble chloride
T 230 m-50	CED Viscosity—Ballfall
T 230 m-50	CED Viscosity—Capillary
T 235 m-58	18% Caustic solubility
T 235 m-58	10% Caustic solubility

Analytical data on Alcohol Solubility could not be interpreted due to failure by most participants to follow the procedure given in T 204. Analytical data submitted on 10% Caustic Solubility were too few to be worth including in the statistical analyses. Data submitted on Water-Soluble Sulfates indicated only a trace amount and no statistical analysis of this characteristic was made.

The analytical data received from each participant are given in the appended Tables III–XIII. Each laboratory's performance, in relation to the average for all laboratories (the sample average), is shown as the deviation from the sample average in column 5 of these tables.

Laboratories which reported the use of test procedures other than the standard TAPPI methods, or modifications of these standard methods were not included in the statistical treatment of the data. Laboratories which reported results which differed from the sample average by greater than 3 standard deviations were not included in the statistical analysis.

Table III. Alpha Cellulose T 203 m-44

Lab. no.	*1st Test*	*2nd Test*	*Test av.*	*Deviation from sample av.*
6	86.20	86.40	86.30	−0.46
7	86.40	86.20	86.30	−0.46
14	88.71	88.08	88.40	+1.64
16	86.78	86.83	86.81	+0.05
18	85.79	85.84	85.82	−0.94
19	88.20	88.30	88.25	+1.49
22	86.15	86.10	86.13	−0.63
23	86.97	86.89	86.93	+0.17
25	86.40	86.30	86.35	−0.41
31	86.33	86.31	86.32	−0.44

Sample average, 86.76; standard deviation, 0.882.

Table IV. Alpha Cellulose T 203 m-58

Lab. no.	*1st Test*	*2nd Test*	*Test av.*	*Deviation from sample av.*
1	86.34	86.31	86.33	+0.141
2	85.60	85.60	85.60	−0.589
4	87.60	87.57	87.59	+1.401
5	85.76	86.05	85.91	−0.279
8	86.00	86.06	86.03	−0.159
9	86.00	85.90	85.95	−0.239
10	85.90	85.90	85.90	−0.289
20	87.57	87.52	87.55	+1.361
21	85.80	85.50	85.65	−0.539
30	86.20	86.10	86.15	−0.039
33	86.50	86.38	86.44	+0.251
35	85.50	85.63	85.57	−0.619
44	86.30	86.20	86.25	+0.061
45	86.08	86.14	86.11	−0.079
47	85.80	85.80	85.80	−0.389

Sample average, 86.189; standard deviation, 0.615.

Table V. Ether Solubility T 204 m-54

Lab. no.	*1st Test*	*2nd Test*	*Test av.*	*Deviation from sample av.*
1	0.31	0.29	0.30	−0.007
2	0.29	0.33	0.31	+0.003
4	0.19	0.22	0.21	−0.097
5	0.28	0.32	0.30	−0.007
6	0.40	0.45	0.43	+0.123
7	0.37	0.25	0.31	+0.003
8	0.20	0.18	0.19	−0.117
9	0.42	0.40	0.41	+0.103
10	0.35	0.33	0.34	+0.033
14	0.28	0.24	0.26	−0.047
16	0.31	0.31	0.31	+0.003
18	0.37	0.37	0.37	+0.063
19	0.24	0.24	0.24	−0.067
21	0.33	0.31	0.32	+0.013
23	0.24	0.23	0.24	−0.067
24	0.33	0.34	0.34	+0.033
27	0.21	0.32	0.27	−0.037
29	0.36	0.35	0.36	+0.053
31	0.19	0.21	0.20	−0.107
32	0.27	0.25	0.26	−0.047
34	0.32	0.28	0.30	−0.007
35	0.29	0.31	0.30	−0.007
36	0.34	0.35	0.35	+0.043
39	0.31	0.35	0.33	+0.023
44	0.41	0.33	0.37	+0.063
50	0.39	0.36	0.38	+0.073
60	0.28	0.29	0.29	−0.017

Sample average, 0.307; standard deviation 0.0606.

Table VI. Ash T 211 m-54

Lab. no.	*1st Test*	*2nd Test*	*Test av.*	*Deviation from sample av.*
1	0.26	0.25	0.26	+0.087
2	0.15	0.16	0.16	−0.013
4	0.14	0.14	0.14	−0.033
5	0.18	0.21	0.20	+0.027
6	0.16	0.15	0.16	−0.013
7	0.14	0.15	0.15	−0.023
8	0.17	0.16	0.17	−0.003
9	0.16	0.16	0.16	−0.013
10	0.20	0.19	0.20	+0.027
13	0.16	0.19	0.18	+0.007
14	0.13	0.13	0.13	−0.043
16	0.16	0.16	0.16	−0.013
17	0.14	0.14	0.14	−0.033
18	0.16	0.17	0.17	−0.003
19	0.18	0.16	0.17	−0.003
20	0.23	0.25	0.24	+0.067
21	0.17	0.17	0.17	−0.003
24	0.31	0.29	0.30	+0.127
25	0.22	0.17	0.20	+0.027
27	0.17	0.17	0.17	−0.003
29	0.15	0.15	0.15	−0.023
31	0.16	0.15	0.16	−0.013
32	0.14	0.14	0.14	−0.033
33	0.15	0.15	0.15	−0.023
34	0.23	0.20	0.22	+0.047
35	0.26	0.26	0.26	+0.087
36	0.16	0.15	0.16	−0.013
37	0.16	0.16	0.16	−0.013
38	0.12	0.12	0.12	−0.053
39	0.16	0.16	0.16	−0.013
42	0.12	0.14	0.13	−0.043
43	0.19	0.19	0.19	+0.017
44	0.16	0.17	0.17	−0.003
49	0.13	0.13	0.13	−0.043
50	0.17	0.19	0.18	+0.007
53	0.14	0.16	0.15	−0.023
55	0.14	0.14	0.14	−0.033
56	0.18	0.17	0.18	+0.007
57	0.16	0.14	0.15	−0.023

Sample average, 0.173; standard deviation, 0.0384.

Table VII. 1% NaOH Solubility T 212 m-54

Lab. no.	*1st Test*	*2nd Test*	*Test av.*	*Deviation from sample av.*
1	8.63	8.54	8.59	+0.47
2	10.00	9.90	9.95	+1.83
4	5.61	5.63	5.62	−2.50
5	9.00	9.40	9.20	+1.08
6	9.15	9.75	9.45	+1.33
7	7.53	7.54	7.59	−0.58
8	9.08	9.08	9.08	+0.96
10	8.60	8.50	8.55	−0.43
13	6.93	7.12	7.03	−1.09
16	9.07	9.25	9.16	+1.04
18	5.68	5.61	5.65	−2.47
19	8.60	8.10	8.35	+0.23
21	8.63	8.91	8.77	+0.65
22	9.84	9.74	9.79	+1.67
27	7.10	7.20	7.15	−0.97
29	5.72	5.47	5.60	−2.52
34	8.75	8.46	8.61	+0.49

Sample average, 8.12; standard deviation, 1.442.

Table VIII. Copper Number T 215 m-50

Lab. no.	1st Test	2nd Test	Test av.	Deviation from sample av.
1	2.24	2.18	2.21	+0.32
2	1.80	1.80	1.80	−0.09
4	2.23	2.09	2.16	+0.27
5	1.54	1.42	1.48	−0.41
6	1.40	1.40	1.40	−0.49
7	1.74	1.73	1.74	−0.15
8	2.20	2.20	2.20	+0.31
10	2.00	2.00	2.00	+0.11
13	1.40	1.20	1.30	−0.59
20	1.47	1.54	1.51	−0.38
21	2.10	2.10	2.10	+0.21
22	2.06	2.11	2.09	+0.20
30	2.25	2.23	2.24	+0.35
32	2.09	2.12	2.11	+0.22
33	2.14	2.13	2.14	+0.25
37	1.83	1.83	1.83	−0.06
48	1.91	1.86	1.89	0.00

Sample average, 1.89; standard deviation, 0.310.

Table IX. Pentosans T 223 m-58

Lab. no.	1st Test	2nd Test	Test av.	Deviation from sample av.
1	2.44	2.33	2.39	−0.10
2	3.70	3.50	3.60	+1.11
4	2.10	2.40	2.25	−0.24
5	1.78	1.96	1.87	−0.62
6	2.34	2.74	2.54	+0.05
7	2.23	2.19	2.21	−0.28
8	1.84	1.82	1.83	−0.66
10	2.10	2.10	2.10	−0.39
16	2.38	2.38	2.38	−0.11
19	2.75	2.75	2.75	+0.26
20	3.10	2.60	2.85	+0.36
25	2.86	2.81	2.84	+0.35
35	2.87	3.02	2.95	+0.46
45	2.45	2.40	2.43	−0.06
47	2.37	2.39	2.38	−0.11

Sample average, 2.49; standard deviation, 0.455.

Table X. Water-Soluble Chlorides T 229 m-45

Lab. no.	1st Test	2nd Test	Test av.	Deviation from sample av.
1	0.041	0.043	0.042	+0.0124
2	0.023	0.026	0.025	−0.0046
5	0.070	0.060	0.065	+0.0354
9	0.050	0.050	0.050	+0.0204
13	0.020	0.020	0.020	−0.0096
18	0.025	0.040	0.033	+0.0034
21	0.013	0.013	0.013	−0.0166
24	0.030	0.035	0.033	+0.0034
27	0.017	0.015	0.016	−0.0136
29	0.020	0.020	0.020	−0.0096
34	0.028	0.028	0.028	−0.0016
36	0.021	0.022	0.022	−0.0076
38	0.020	0.020	0.020	−0.0096

Sample average, 0.0296; standard deviation, 0.0149.

Table XI. Viscosity—Ballfall T 230 m-50

Lab. no.	1st Test	2nd Test	Test av.	Deviation from sample av.
2	107.0	107.0	107.0	+4.7
4	93.0	94.0	93.5	−8.8
18	98.0	92.0	95.0	−7.3
19	71.0	71.0	71.0	−31.3
31	112.0	116.0	114.0	+11.7
37	116.0	114.0	115.0	+12.7
49	121.0	120.0	120.5	+18.2
58	101.9	102.5	102.2	−0.1

Sample average, 102.3; standard deviation, 15.88.

Table XII. Viscosity—Capillary T 230 m-50

Lab. no.	1st Test	2nd Test	Test av.	Deviation from sample av.
1	15.7	15.7	15.7	+0.87
4	15.2	15.1	15.2	+0.37
5	14.4	14.4	14.4	−0.43
7	13.6	13.6	13.6	−1.23
9	15.0	14.9	15.0	+0.17
13	14.0	13.6	13.8	−1.03
14	15.8	15.8	15.8	+0.97
17	14.7	14.7	14.7	−0.13
20	15.9	15.6	15.8	+0.97
22	15.3	15.7	15.5	+0.67
23	15.8	16.0	15.9	+1.07
25	14.1	14.9	14.5	−0.33
39	14.6	14.7	14.7	−0.13
42	15.0	14.9	15.0	+0.17
43	12.9	12.7	12.8	−2.03
47	15.1	15.0	15.1	+0.27
48	14.4	14.4	14.4	−0.43
52	16.4	16.1	16.3	+1.47
58	13.6	13.6	13.6	−1.23

Sample average, 14.83; standard deviation, 0.914.

Table XIII. 18% Caustic Solubility T 235 m-58

Lab. no.	1st Test	2nd Test	Test av.	Deviation from sample av.
1	11.50	11.47	11.49	−0.11
2	11.60	11.60	11.60	
3	11.10	11.00	11.05	−0.55
8	12.12	12.00	12.06	+0.46
9	12.20	13.00	12.60	+1.00
10	11.40	11.40	11.40	−0.20
14	10.46	10.73	10.60	−1.00
18	11.84	11.76	11.80	+0.20
22	11.70	11.70	11.70	+0.10
27	11.60	11.60	11.60	0.00
45	11.82	11.64	11.73	+0.13

Sample average, 11.60; standard deviation, 0.513.

DISCUSSION

Average values for the chemical characteristics of the TAPPI Reference Pulp are summarized in Table I.

The values given in columns 6 and 7 of Table I are plus or minus twice the standard error of the sample average. These values give some indication of the precision with which the mean value of the TAPPI Reference Pulp is known.

Because of the relatively wide limits about the sample average (i.e., alpha cellulose, T 203 m-58, the limits of ±2 standard errors are 85.88 and 86.50), these data do not provide a sufficiently accurate estimate of the chemical characteristics of the TAPPI Reference Pulp to enable its use as an absolute calibration standard.

The wide limits about the sample average can be shown to arise in the variability of the data submitted by the participating laboratories for each procedure. Because of this, the use of the TAPPI Reference Pulp as an approximate calibration standard may have value in substantially reducing the differences which exist among laboratories using these procedures.

An index of the variability among laboratories can be derived from an estimate of the components of variability for each procedure, as given in Table II.

The data given in Table II indicate that the within laboratory variability is small when compared with the variability among the participating laboratories. The ratio of the among laboratory variability to the within laboratory variability should be 1.0 for a test capable of yielding a precise value under ideal conditions. Where this ratio becomes increasingly large, it may be inferred that each laboratory is adopting modifications of the procedure which alter the results, or that the test procedure is too ill-defined and loose to be followed precisely.

RC 298. Benzene Solubility of Petroleum Wax

The object of this method is to determine the solubility of petroleum wax in benzene, by dissolving the wax in benzene, filtering the solution, weighing the residue, and calculating the percentage of solubility.

Test Specimen

One gram of petroleum wax.

Apparatus

Analytical balance; tared Gooch crucible; glass cylinder, 100 ml.; desiccator; oven capable of maintaining a temperature of 103 ± 3°C.; suction flask.

Procedure

Dissolve 1 ± 0.2 g. weighed to the nearest milligram of the specimen in 100 ml. of benzene. Filter solution through a tared Gooch crucible using a suction flask, and wash the residue with separate portions of benzene until the washings are colorless. Remove the benzene from the crucible by continued suction. Dry the residue in the oven at 103 ± 3°C., cool in a desiccator, and weigh to the nearest milligram. Calculate the percent soluble in benzene as follows:

Per cent soluble in benzene = $100(A - B)/A$, where A = weight of specimen in grams and B = weight of residue in grams.

RC 299. Hardness Index of Pulp Mullen Test Method

This is a method by which sheet pulp may be classified according to relative hardness as a criterion of the ease with which it may be ultimately ground or shredded. The relative hardness is expressed and recorded as a ratio between the Mullen bursting strength and the thickness of the sheet. For classification purposes, this relationship is called the Hardness Index.

Equipment

Mullen board burst tester—Model A (motor driven) or jumbo type (hand driven)

Bursting pressure gage of suitable range*

Paper thickness gage—dial type

Sample Preparation

The specimen shall be of sufficient size as to allow a total of 10 bursts to be made. Allow an area not less than 4 in. by 4 in. for each burst.

Condition the sheet (or sheets) at 50% R.H. at 73°F. for 16 hr. or longer. (Refer to TAPPI Standard T 402 m "Conditioning Paper and Paperboard for Testing.")

Proceedure

Measure and record the thickness of the specimen in five test areas on the wire side of the sheet. (Refer to TAPPI Standard T 411 m "Thickness and Density of Paper.")

Mark with a soft lead pencil the exact position where the measurements are made.

Repeat the procedure on an equal number of test areas on the felt side of the sheet. If a single large sheet is used for all tests, be sure that the marked test areas do not overlap areas previously measured.

Place the specimen of the diaphragm plate of the Mullen tester so that one of the marked areas coincides with the center of the plate hole. Lower the upper clamping plate by rotating the clamp wheel and apply a firm clamping pressure to the sheet to prevent slippage of the sample during the test.

Burst the sample following the procedure outlined in the Mullen tester manufacturer's operating instructions. Record the bursting strength to the nearest pound as indicated by the pressure gage.

Repeat the procedure in each of the designated test areas.

Calculation of Hardness Index

$$\text{Average bursting strength} = \frac{\text{Sum of bursting strength readings}}{\text{Number of readings}}$$

$$\text{Average thickness} = \frac{\text{Sum of thickness readings}}{\text{Number of readings}}$$

$$\text{Hardness index} = \frac{\text{Average bursting strength}}{1000 \times \text{average thickness in inches}}$$

Example

Average bursting strength = 54 p.s.i.
Average thickness = 0.051 in.

$$\text{Hardness index} = \frac{54}{1000 \times 0.051} = 1.06$$

* The gage used should be such that each bursting strength reading shall not be less than 25% or not more than 75% of the total capacity of the gage.

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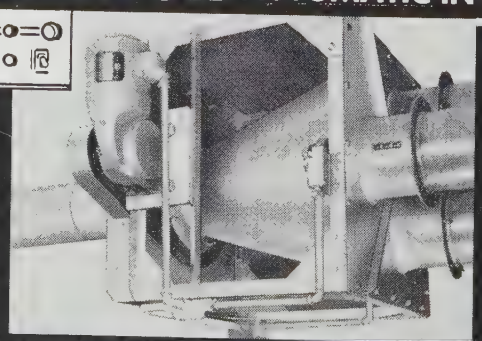

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LOCAL SECTION ACTIVITIES

Ohio

Harold M. Annis, president-elect of TAPPI and vice-president, Research and Development, Oxford Paper Co., talked to a record attendance of 300 at the February 9 meeting of the Ohio Section of TAPPI at the Hotel Manchester in Middletown. His address, which was followed by an informative question-and-answer session, follows.

Following the talk by Mr. Annis, the group was treated to an unusual bit of entertainment. Lyal Clark, present defensive line coach at Ohio State, showed a silent movie of the classic 1935 Notre Dame football victory over Ohio State. Lively authentic commentary was provided by Bill Shakespeare. Notre Dame halfback; Frank Antenucci, Ohio State fullback; and Ted Hieronymus, Ohio State assistant coach. All were participants in that game which was decided by a touchdown in the final minute of play.

THOMAS H. WEISMAN, *Recording Secretary*

Paper Coating and the Trailing Blade Method

Harold M. Annis

The history of paper machine coating is discussed briefly with a limited evaluation of the trailing blade method.

I AM highly honored to be with you this evening and I am really here with several hats on. First, as president-elect of TAPPI, I would like to bring to all of you friendly greetings and best wishes from the officers, Executive Committee members, and fellow members of TAPPI throughout the world. There are some 11,000 of us by now with about 2000 overseas.

The Ohio Section of TAPPI is well known throughout the industry and throughout the Association as a tower of strength in TAPPI activities directed toward attaining the goals of our Association. As president-elect, I want to go beyond bringing you best wishes and want to particularly bring you heartiest congratulations on the excellent job that has been done by this section for TAPPI and the soundness of your approach to continue vigorously this effort.

My second responsibility tonight is the pleasant task of presenting an award to Virgil Perry for his outstanding work as chairman of the Ohio Section during the 1959–60 season. (Virgil accepted the award and expressed his thanks to those who supported his efforts.)

Thirdly, I am here as a coating speaker. As a native of Ohio, I want to tell you how glad I am to be back on Ohio soil, and how glad I was to get the invitation to be with you tonight. As you may know, my home town is Chillicothe, and my wife is from Dayton. We got tangled up in the New York race some 25 years ago, but that does not change one iota our high regard and fine recollection of the State of Ohio, and the important part that the paper industry plays here.

Your committee wanted me to talk tonight about coating. In my career any discussion of such nebulous problems as coating or graphic arts always brings out a good sized group and some particularly interesting discussions, both of these are areas of some complexities—growth, rapid change of technology, and incidentally, some controversy.

I would be presuming to try to speak to you as a coating expert with full knowledge that some of the outstanding manufacturers of coated paper in the United States, such as Mead and Champion, are represented in this audience. So I'll speak to you as one coating man to another. It has been my experience since I first came in contact with coating in 1923 that when coating men get together, they always have an interesting exchange of experiences, approaches, and points of view. Most likely very little of what I will have to say will be new to some of you. Still, it may be a useful picture for some of the younger men.

A rather substantial part of my remarks tonight may relate to the trailing blade method of coating. I am not trying to sell it to anybody, since each of us, with our own grade structure, our own sales objectives, and with our own pulp picture, has a different set of basic conditions and a different set of objectives with a definite possibility that we may reach these objectives through different approaches.

My first contact with coating was in 1923 at Mead in Chillicothe. At that time, I was fresh out of high school and worked with coating experts from the United States and other countries trying to learn the game of conversion coated. At that time, Mead was doing some important forward work on new methods of conversion coating. This differed from brush coating, which was standard practice in that period, but was largely in the field of what we today call "off-the machine coating," part of which at that time was directed at commercial printing grades as differentiated from publication grades.

As the years went by, there came the early work in attempting to coat paper on the paper machine itself rather than in a separate operation. I distinctly recall the early steps in which the approach started in the press section of the machine. However, the birth and big impetus of machine coated was in the middle 1930's, at which time relatively simultaneous developments caused the machine coated development to be greatly accelerated. You will recall that *Life* came out in the middle 1930's and, at the same time, web heat-set letterpress was born. This magazine and this new method of printing in rolls, at high speeds, in four colors on each side, created a new demand on paper with respect to printability, press performance, appearance value, and economics. In order to meet these requirements, millions were spent by a number of important paper mills on working out mechanical coating arrangements, coating formulation problems and coating mixture preparation problems in connection with coating on the paper machine itself. Some prominent names in this development period were Mead, Consolidated, and Kimberly-Clark. In all cases, the approach was to do the coating on the paper machine on a dry sheet that had been through a machine calender, to use high solids coating mixtures, and to transfer the coating to the paper surface through a system of rolls.

This machine coated development was of such great significance that the current level of machine coated paper is at least 1,500,000 tons per year, with additional expansion announced by a number of companies and with great activity of considerable volume in the field of coated board. It is, therefore, evident that the coating of paper and paperboard is now a very significant factor in our industry, and it is, therefore, not surprising that many important companies are spend-

HAROLD M. ANNIS, Vice-President, Research and Development, Oxford Paper Co., New York, N. Y.

ing millions on research and development and on production facilities resulting from this research.

It is also not surprising that the machine roll coating method, in spite of its spectacular success, had its complications and limitations which seem in recent years to have caught up with us on quite a few considerations. One of these considerations is the trend of what we are being asked, as papermakers, to build into a sheet of paper and I refer, for example, to the marked down trend in basis weight.

Within the period under discussion, some of the magazine papers were 60-lb. basis weight, but are today more like 40-lb. Even at this reduced weight, the paper is asked to print better, to perform better on the printing press with less web breaks due to paper and with less waste, and to be produced under production conditions that make it economically sound. It will be recognized that the basis weight pressure in the magazine field is directly related to the terrific pressure that the magazine publishers have to face, with respect to increased mailing costs. They have no alternative but to try to keep on top of the problem through basis weight reduction, without sacrificing printability, press performance, opacity, etc. As we faced these problems, it soon became clear that we had to make progress in the manufacture of the base sheet at very high speeds and that we had to improve coating methods to see if we could eliminate the limitations on surface levelness created by the basic film-split problem.

As you all know, in the manufacture of a machine coated sheet, by conventional roll coating methods, not all of the coating is transferred from the rolls to the paper surface. This means that the coating film splits and results in a disturbance to surface levelness, which reflects in printability. It is not surprising to know that many important companies did important work on the rheology of coating mixtures on different roll arrangements to try to minimise this problem. Progress was made, but, particularly with the light basis weight problem, it was important to try to get away from the film-split problem altogether, because, under conditions of light basis weight, coat weights have to be reduced and more is asked of the coating.

It is not surprising that this investigation of the various ways of meeting the problems before us led, some ten years ago, to a number of important companies, including Oxford, undertaking the evaluation of the trailing blade coating method. It was early recognized by those who investigated this method that it had the potential of a remarkable increase in surface levelness of the coated paper and this could be accomplished with a considerable reduction of coat weight. It is not surprising that much of this early work was related to such problems as opaque bread wrap requirements and the problem of lightweight coated paper for the magazine publishers.

As the evaluation of this coating method went forward, some companies, especially Oxford, evaluated its potential in a different part of their grade structure and a different part of the coat weight range. It has now been clearly established that the trailing blade coating method is not limited to light coat weights such as 2 to 5 lb. per side.

It was relatively simple to evaluate the quality potential of the trailing blade coating method by a pilot coater, a means which practically all of us have now found necessary. However, it could not reliably and completely evaluate many operating factors under such conditions.

My first knowledge of a commercial operation of the trailing blade coating method was about 10 years ago at Fraser in Maine on opaque bread wrap. The problem on that grade was to improve such properties as opacity, brightness, and printability with the least possible coat weight and the least disturbance to other valuable properties in the end use of this product. The trailing blade system accomplished this with extremely light coat weights at very high speeds on this grade at Fraser on an off-the-machine, one side only operation. As nearly always happens, with competition, this immediately stimulated other manufacturers of opaque bread wrap to evaluate the trailing blade approach, and I guess it is safe to say that it is in widespread practice today on this product.

The next significant forward step in the trailing blade development was the application of this coating method to the manufacture of coated paper for the magazine publishing field, with its problems of printability, ink hold-out, opacity, press performance, and economics.

To the best of my knowledge, the people who first made the most significant forward step in this field with the trailing blade was Blandin Paper Co. of Grand Rapids, Minn., on the *Look* magazine problem. Not having previously been experienced in the manufacture of coated papers, Blandin started from scratch and selected the approach of a tandem off-the-machine operation. This means that the base sheet was made on the paper machine at fairly good speeds and subsequently coated on the tandem off-the-machine blade coater. As is true of any pioneering effort, quite a few problems were encountered, such as drying, flying paster operation, base paper limitations, coating color preparation, development of blade technology, etc. Blandin succeeded in this pioneering effort in this field in the area of light coat weights and then backed up their original pioneering effort with a second high-speed off-the-machine unit, which operates at well over 2000 f.p.m. Their product is well regarded and, as an "alleged coating expert." I take my hat off to the job that Blandin has done.

Other important companies, in the meantime, had been working with the trailing blade development on-the-machine and off-the-machine and on different parts of the grade structure. An important example in this period would be the new mill at St. Francisville, La., jointly owned by Crown Zellerbach and Time-Life. Other important companies very active on this development at that time would include Mead, Kimberly-Clark, Consolidated, and International. The various companies used different approaches which led to such nebulous questions as off-the-machine versus on-the-machine and double coating versus single coating.

Blandin chose to go up the off-the-machine street and has been successful with it. It is my understanding that Mead is active on both approaches. Kimberly-Clark and Crown Zellerbach are examples of on-the-machine approach, and it may be well to discuss some of the considerations.

St. Francisville, which is a brand new mill, is an example of the on-the-machine approach.

Each mill has its own reasons for the approach that they adopted, and I want to bring to your attention, as coating people, a consideration which cannot be overlooked; the characteristics of the pulp that you are using, with the resulting effect on the base sheet properties, has a very substantial bearing on what arrangement may be required to accomplish your objective. Without appearing too partial, I think those of us who deal with Northeast and Lake States pulps are in a more favorable position in this regard than we commonly recognize. Conversely, and again, without being partial, the fiber properties of long fibered pulps from the West Coast and Deep South create a different set of problems, although it will be recognized that the South has made considerable progress in utilization of hardwood kraft which has more desirable properties for printing papers.

Jack Wilber of St. Regis had a speech published that he made on the subject of "On-the-machine versus Off-the-machine Coating," and I think it is better for you to have a look at this article than to repeat the pros and cons here. Suffice it to say that we do not see any signs of the final answer today, and it will be quickly recognized that what is right for one company in one location is not entirely right for another. It depends in great measure on where you stand, what you have, and where you are going.

The relationship of the trailing blade coating method to an improved level of printing surface is by now well established

by many mills. I do not personally consider that this is no longer a question of controversy, but it would be a mistake to not comment that this significant effect on quality has been accompanied by some very rough operating problems.

From all of these observations and personal experiences, there is one thing that is crystal clear to me, and it is so simple that I'm sure you will probably pass it over as an academic remark. It is quite clear that it is not safe or reasonable to attack a high-speed coating problem, especially on light weights, on or off the machine by any coating method, without first getting your house in order at the wet end of the paper machine with respect to formation, uniformity, profile, roll condition, machine efficiency, and slime spots. Having taken care of this basic situation, I think you then have a decent chance of success, either on or off the machine, whichever choice best fits your own company situation, grades, weights, and objectives.

Presented at the meeting of the Ohio Section of TAPPI, held in Middletown Ohio, Feb. 9, 1961.

Kalamazoo Valley

The December meeting of the Kalamazoo Valley Section of TAPPI was held at Inmans Resturant, Galesburg, Mich., on Dec. 8, 1960. Approximately 80 members were in attendance to consider "Papermaking Characteristics of Pulps." W. A. Lunsford, manager of research and development, Consolidated Paper Co., Monroe, Mich., served as moderator for the following panel:

W. H. Marra, manager of technical service for Central Division, S. D. Warren Co.—Topic: "Hardwood Kraft Pulp."
B. C. McMahon, production manager, American Boxboard Div., Filer City mill, Packaging Corp. of America—Topic: "Hardwood and Softwood Kraft Pulps, and Blends Thereof."
J. C. Tongren, technical director, Watervliet Paper Co., Div. of Hammermill Paper Co.—Topic: "Semichemical Pulp."

Each panel member discussed the physical and chemical characteristics of the subject pulps in the papermaking process. The panelist presentations were a successful stimulant for a most interesting question-and-answer period which followed.

January

The 26th annual papermakers get-together, cosponsored by the Kalamazoo Valley Section TAPPI and the Michigan Division of PIMA was held Thursday evening, January 19, at Kalamazoo's Hotel Harris. Local TAPPI acting chairman, J. D. Chadderdon presided over the record turnout of 500 persons.

Frank Roberts, vice-president, Muskegon manager, S. D. Warren Co., acted as toastmaster and introduced Glen Massman, of Dayton, Ohio, the featured speaker of the evening.

Mr. Massman, a human relations consultant, discussed "Evaluating Personal Potentials in Order to Live a Full Life." He stressed that we must take an optimistic outlook for the future.

He warned that fear drives logic from the mind, and called for individual efforts to utilize faith, enthusiasm, ambition and resourcefulness as an antidote to fear.

National officers in attendance were R. G. Macdonald, treasurer, TAPPI; Harry Weston, executive secretary and treasurer, PIMA; Harris Ware, technical manager, Beveridge Paper Co., TAPPI Executive Committee, and Alfred H. Nadelman, TAPPI Executive Committee.

A. H. Hupp, *Secretary*

Lake States

The Past Chairmen of the Lake States Section of TAPPI were honored as it was the 30th Anniversary of the Section.

(Sitting) Henry Crandall, Mosinee Paper Mills; R. G. Macdonald, treasurer of National TAPPI; Walter Bublitz, Minnesota Mining & Mfg. Co.; Herbert Rowe, Nekoosa Edwards Paper Co. (Standing) S. R. Parsons, Consolidated Water Power & Paper Co. and S. J. Baisch, S. J. Baisch Associates

There were 201 people in attendance for the dinner at the Appleton Elks Club. After dinner, John Swanson gave a talk on beater adhesives the full text of which was published in the January issue of *Tappi*.

J. F. Whalen, *Secretary*

Chicago

Chicago Section of TAPPI was held at the Chicago Bar Association of Jan. 10, 1960. The subject of the meeting was "Training for Career Opportunities in Pulp, Paper and Packaging." The speakers included: Alfred H. Nadelman, Head of Paper Technology, Western Michigan University; John R. Fanselow, Associate Professor, Department of Paper Technology, Western Michigan University; and James W. Gofi, School of Packaging, Michigan State University.

These speakers gave talks on the educational opportunities offered by these Midwestern Universities for college training of young people seeking a career in the 15 billion dollar paper and packaging industry. Many advantages are

C. J. West, Jr., Kimberly-Clark Corp.; R. A. Nugent, Nekoosa Edwards Paper Co.; John W. Swanson, Institute of Paper Chemistry; George Sears, Institute of Paper Chemistry; Robert Leaf, Shawano Paper Mills

offered both to students and industry by this specialized training.

The program was well attended by members and also 16 high school counselors who were guests of the section. Also attending was Dr. Macdonald, treasurer of National TAPPI.

PAUL M. GRONENDYKE, *2nd Vice-Chairman*

European Study Group

Training of the Academic Paper Engineer

Karl J. Adamik

The paper engineer requires a modification of the education required for a chemical engineer and a mechanical engineer. A comparison is given of the main subjects in the various field of study in engineering. The subjects required for a paper engineer are outlined and a comparison of the lecture hours of several institutions are given.

IN THE wide field of consumer goods production, the pulp and paper industry occupies a very important position. In the consumer goods industries, chemistry and the machinery industry cooperate over a large field. To produce effective teamwork, technical management must therefore include chemists and machine engineers as well as paper engineers who, in this case, represent a modification of the process engineer.

For the solution of purely chemical questions, the academic chemist will be called upon. He will carry out chemical development and research and he will have under his control the chemical laboratories for day to day control work. The chemist, who is engaged directly in production, after some years of work in responsible positions, develops into a chemical technologist.

Machine engineers and electricians will be used for the supervision of the pure machine phases of the work, for example, the power house, transport installation, workshops, and power lines.

For the management of the production plant, the paper engineer will primarily be used. The latter therefore is the link between the pure chemist and the pure machine engineer.

In order to assess the potentialities for the pulp and paper industry of students from various fields, the main subjects involved in their respective studies are compared in Fig. 1.

This comparison shows clearly what qualities the students from these various fields can offer as potential managers in the pulp and paper industry. The comparison also evokes a certain amount of criticism over the distribution of the main subjects. Apart from the chemists, the machine engineer and the process engineer, in this case the paper engineer, larger works which have suitable research development facilities will also require physical chemists and technical physicists.

Chemistry. Let us begin with chemistry. Here we notice above all the small amount of time devoted to mathematics. Greater emphasis on training in physics, and particular training in physical chemistry, would also seem to be necessary. It would be more appropriate to the training of the chemist if a part of the time devoted to chemical technology would be set aside for the basic principles of process engineering.

Physical Chemistry. The physical chemist requires an even more pronounced training in physics. He must already be familiar with the basic principles of power and machinery. The physical chemist provides the required fundamental knowledge for both the chemist, particularly the technical chemist, and the process engineer.

Technical Physics. Training in technical physics must provide for development in various directions by the provision

KARL J. ADAMIK, Professor of Paper Technology, Technical University, Graz, Austria.

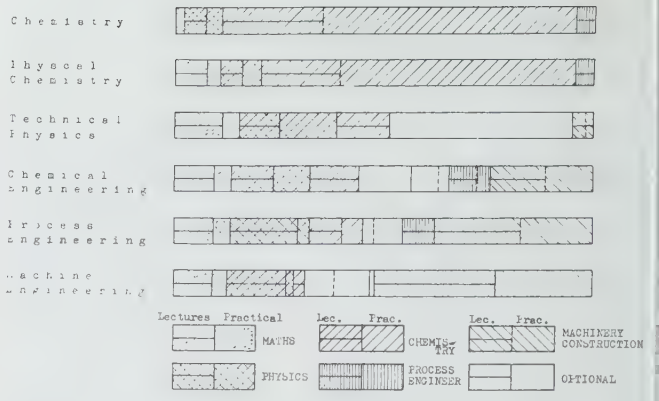

Fig. 1. Comparison of main subjects of various fields of study

of optional subjects so that students are able to choose between work where the emphasis is in chemical, or mechanical or electrical respects. The remarks concerning the training of the physical chemist in the basic principles of machinery apply in even greater measure to the technical physicist.

Chemical Engineer. Figure 1 shows the division of scientific subjects in the United States and the more intensive fundamental chemical education. The training of chemical engineers is in the hands of chemistry faculties. The optional subjects are for instance petrochemistry, as relevant to the petroleum industry and chemical technology of petroleum.

Process Engineer. In Germany, the process engineer is trained fundamentally as a machine engineer, receiving also the required instruction in chemistry, particularly physical chemistry. A suitable period of time must be set aside for special subjects, for example pulp and paper technology in the case of the paper engineer.

Machine Engineer. The machine engineer should also be given a basic idea of process engineering and chemistry since modern developments require the use of chemical products in ever increasing measure and since the chemical industry is becoming increasingly involved in meeting the vital demands of the peoples of the world with the result that there is a growing demand for machine engineers in the consumer goods industries.

In the following remarks, we intend to deal with the training of the paper engineer, a special type of process engineer.

What sort of training is required of the paper engineer? What must he do in order not to prolong his period of study unduly and yet to achieve a certain degree of harmony between the various subjects. Above all, what tasks will he be called upon to solve?

The paper engineer must create and control the physical conditions under which the technological processes take place: heat, refrigeration; pressure, vacuum; mechanical and electric energy. He must also solve transport questions concerning raw materials, auxiliary materials, finished materials, and waste materials.

A tricky problem is the supply of water needed in production, and the discharge of waste waters. To this must be added all the problems concerning special machinery and equipment, their development and construction, as well as the planning and maintenance of plant.

The economic importance of the work of the paper engineer is greatly emphasized if one considers the costing of the product:

1. Capital expenditure on machines and equipment
2. Development costs and experiments
3. Creation of the physical conditions
4. Transport
5. Consumption of energy and water
6. Discharge of waste products and waste waters.

The field of the paper engineer is not simply a combination

of physics, chemistry, and machine engineering but must be considered as a special case of process engineering techniques, as a separate homogeneous subject. In the field of consumer goods production the basic operations of process engineering are always the same whether we deal with the paper and pulp, rubber, food, or chemical industries.

Let us for instance consider sheet formation on a paper-making machine and let us attempt to analyze the process that takes place into elementary steps so that we can separate the partly overlapping processes and evaluate them according to their importance. It is only by such an analysis that individual aspects can be elucidated through technical experiments so that the basis for novel designs is created. This approach has led to the great successes of engineering in the field of modern process engineering techniques.

Analysis of Process Engineering Factors Involved in the Sheet Formation Process

Task	*Physical Behavior*	*Technical medium*
Suspension formation	Furnishing liquid-solid phase	Chests, consistency regulator, mixing system, pulp center
Suspension cleaning	Pulp separation	Screen
Pulp transmission to the screen	Flow	Pulp regulation box, distribution box, channels and pipes, pulp discharge
Sheet formation	Sedimentation	Classifying, supporting, and movement installations
Dehydration	Filtration Pressing—mechanical Drying—thermal	Tube rolls, suction boxes, couch and wet-press rolls Dry end

All these various elementary processes are continuous. Therefore, if the installation is to work satisfactorily, they must be adjusted to each other. The individual physical steps interlock and overlap. Separate observation is therefore not always possible.

Let us take as an ideal case the education and training of an outstanding process engineer.

Carl Bosch, the founder of large-scale chemical industry was first trained as a machine technician before he studied chemistry. At the height of his success, when the chemical processes developed by him were being realized on a large scale, he again and again emphasised how much he owed to his engineering training and engineering outlook.

Or Arnold Eucken, to whom the development of process engineering in Germany owes a great deal. In the preface to the last section of his massive work "The Chemical Engineer," produced jointly with Max Jakob, he very definitely refutes in a description of the requirements made upon his collaborators, the strict division of labor between engineer and chemist, demanded 40 years ago by Duisberg. Each collaborator had to have complete mastery of the theme treated by him in respect of chemistry, physical chemistry, and engineering. And this both from the point of view of theory and on the basis of personal practical experience.

Professor R. Plank, Technical High School Karlsruhe, in his lecture "Process Engineers on the Frontiers of Chemistry and Technology," which he gave on the occasion of the Annual Meeting in Hamburg in 1956 of the Process Engineers, showed a graph (Fig. 2) which clearly indicates the proportion of chemical knowledge in the fundamental studies of process engineering and the effect that a variation in this proportion has on the quality of training. The quality of the training was plotted above the amounts of specific knowledge taught. This applies in equal degree to the process engineer and the chemical technologist since both can be considered as an intellectual two-component system.

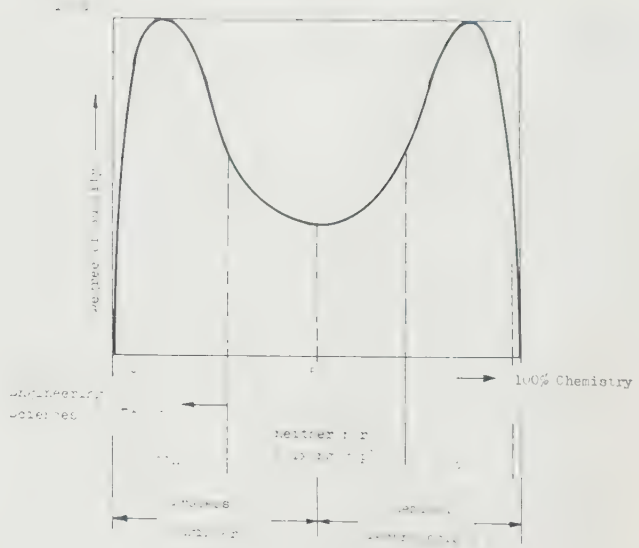

Fig. 2

The course of the graph need not be symmetrical. The position of the maxima can be derived only from experience. Professor Plank estimates them on both sides near 10 or, at the most, 15%. The acquisition of more comprehensive chemical knowledge at the expense of engineering studies then leads to a reduction in his qualification as process engineer. The budding chemical technologist must also be inducted into the thinking of the machine engineer and must learn his language and his methods. But he does not become a chemical technologist until he has performed very many years of independent responsible work in the chemical industry. Chemical technologists cannot be trained in the laboratory.

The fundamental training of the paper engineer is the same as that of the machine engineer but his constructive and technological training is different.

The paper engineer should not occupy himself with chemistry either as a side line or by way of preference. On the other hand, he must have a more comprehensive knowledge of chemistry than the machine engineer and this must be taken into account during his training. It involves a corresponding fundamental education in chemistry, knowledge of the bases of physical chemistry and the performance of a certain volume of laboratory work. The physical-technical training should also include analogous physics since knowledge won in small-sale experiments must be exploited for the design of the machinery and apparatus. This is made possible by analogons physics which permits the translation of laboratory results according to the model laws. The simultaneous fulfilment of several model laws when static, dynamic, thermodynamic, and reaction-kinetic processes are observed on a machine at the same time will never be possible. In this respect, complete similarity cannot be expected. Nevertheless, it should be possible to emphasize certain important characteristics of the plant by distrinctive similarity constants and to neglect

Table I. Comparison of Lecture Hours in Paper Technology at the Technical High School of Darmstadt and the Technical University of Graz

Subject	*Darmstadt*		*Graz*	
	Lectures	*Practical work*	*Lectures*	*Practical work*
I Chemistry	17	34	22	32
II Paper technology	22	32	19	31
III General machinery construction	26	9	31	19
Sum I + II + III	65	75	72	82
Sum II + III	48	41	50	50
Quotient $\frac{I}{I + II + III}$	26%	45%	30.5%	36%

Table II.

	Chemical engineer		Process engineer			
	MIT	*I11.IT*	*Karlsruhe*	*Idealplan Braunschweig*	*Magdeburg*	*Graz*
Total lecture hours	211	213	218	218	298.5	297
Extraneous subjects	42	20	26	18	41	4
Technical optional	31	24	16	42	8	
Technical compulsory	138	169	176	158	249.5	293
Jointly Chemist, Process engineer, Machine engineer	46		12			
Jointly Process engineer, Machine engineer	10		124			
Jointly Chemist, Process engineer	16					
Mathematics	12	18	25	18	27	37
Physics	24	34	33	40	32.5	53
Chemistry	60	57	27	22	26	55
Processing	36	30	11	28	40	41
Machinery construction	6	30	80	50	49.5	126
Practical work		74	50	61	49.5	126

the less significant characteristics which would only complicate the overall picture.

Model experiments also make possible the solution of problems that cannot be strictly or approximately imitated from the model. By the systematic variation of a vital constant, it is possible to arrange model experiments that give numerical values suitable for translation of the process into terms of large-scale manufacture.

The paper engineer should also receive through fundamental training in theoretical dynamics, heat transmission, thermodynamics and complex mixtures, diffusion, absorption etc., all of which will enable him to solve problems of plant design for he must to a considerable extent concern himself with plant construction.

Materials are one of the most important aspects in process engineering techniques for all processes, from the movement of the material, the thermal influence, and the separation or combination of raw material right up to the finished product stage, make the highest demands on the materials used. This includes the problems of corrosion and manufacturing processes, welding techniques occupying a very prominent position.

The comprehensive tasks in the field of measurement and control techniques can be fulfilled only as a result of appropriate training.

The tasks with which the process engineer will in future have to deal require that he should forsake purely empirical methods and find the solution to his problem according to strictly scientific principles. Let me refer you to the scientifically controlled processes without which the introduction of automation would not have been possible.

In training, therefore, there must be, compared with the training of the machine engineer, some reduction in the amount of machine constructional matter taught even if thorough familiarity with the basic machinery elements remains indispensable.

CHEMICAL TRAINING

Let us now turn to the fundamental chemical training that the paper engineer should have. In the main, he must be made to understand the reactions that take place during manufacture. In this, a certain degree of compromise is necessary with regard to time. It must always be borne in mind that the paper engineer is not a chemist. He must, however, be able to follow chemical processes since these play a role in all stages of production. In his training, therefore, the bases of these processes must be taught. Chemical laboratory work is unimportant and his chemical education should be confined to a fair measure of chemical theory supplemented by limited laboratory training so that later the paper engineer is able also to perform chemical production control.

Since the paper engineer will not be able to have a classical chemical education and since, on the other hand, he must be able to understand chemical processes that frequently invade the field of physics, he needs to be familiar also with the bases of physical chemistry and he should, wherever possible, consolidate knowledge in this field by a course of practical physical chemistry. The subject matter with which he should treat can be described by the following headlines:

1. Thermodynamics of mixtures (as a complement to technical thermodynamics)
2. Knowledge of chemical equilibria
3. Structure of matter
   (a) Physical chemistry of interfaces
   (b) Theory of mass transportation
   (c) Theory of specific heat
4. Reaction kinetics

In the field of organic chemistry, he should above all learn something about the function of the various radicals. For paper manufacture he must, however, be fully familiar with the chemistry of the polysaccharides. Modern developments have made it absolutely indispensable that he should also know the chemical paper auxiliaries which are used for finishing of the paper, as well as the appropriate finishing processes themselves.

TRAINING IN FIBER TECHNOLOGY

The paper engineer should also be trained in fiber technology. A start should be made with an introduction to the structure and metabolism of the most important woods and fibers. A knowledge of biology, the anatomy of plants, and the various types of woods is necessary for an understanding of digestion. The technology of cellulose and of paper must be dealt with very broadly with special reference to the technology of chemical digestion, cleaning, and bleaching, and in the technology of paper fiber selection, fiber composition, pulp furnish, type of grinding for the various paper grades, selection of filler and treatment, sizing of various grade of paper, coloring, different methods of dehydration and pressing of the paper web drying, and surface finish.

In Graz, the paper engineer receives his basic training jointly with the students of machine engineering up to the stage of the first state examination. He is excused only from special lectures and practical work concerned with flow and piston machines. From the third years of study onwards he is then trained in the following fields: (1) chemistry, (2) technology of pulp and paper, (3) machines and plant for pulp and paper, and (4) process engineering techniques.

Table I gives a comparison of the term hours devoted to paper and pulp technology at the Technical High School in Darmstadt and the Technical University in Graz, respectively.

From this table it will be seen that both the amount of lectures and of practical work is higher at the Technical University in Graz than at the Technical High School in Darmstadt. The paper engineers trained at Graz receive a more comprehensive training in machine engineering so that the total volume of study at Graz is higher than at Darmstadt. This is not necessarily an advantage, but is due to the fact that the paper engineers attend the lectures originally arranged for machine engineers.

If the total lecture time for chemical engineers at the Massachusetts Institute of Technology and the Illinois Institute of Technology are contrasted with the syllabus in Karlsruhe, the ideal syllabus in Brunswick and the syllabus in Magdeburg and Graz, then it will be seen that the Graz University shows the highest figure. In the Magdeburger syllabus the larger amount of time spent on extraneous subjects, i.e., 41 hr., is rather interesting. By comparison, the number of hours spent in this way in Graz, is only 4.

The important thing is that the paper engineer at the Technical University in Graz receives a far more comprehensive mathematical training, has to master a considerable amount of study in physics and the chemical tuition is also more extensive than in the other high schools. It is of course obvious that this extra amount of tuition, as will be seen from Table III, is accounted for by homework.

The paper engineer should receive a thorough education in the basic subjects so that he will be able to arrive at practical solutions even when faced by new problems.

Presented at the meeting of the Study Group of European TAPPI Members, held in Lucerne, Switzerland, Sept. 12–16, 1960.

Empire State (Central District)

The Two Principal Resources of the Pulp and Paper Industry—Wood and Water—and Their Relationship to the Future Growth of the Industry in New York State

Neil J. Stout

The wood resources of the Adirondack region of New York State in reference to the paper industry are reviewed historically and reference is made to the activities of the Pomeroy Committee which is concerned with the perpetuation of wilderness areas.

As a forester, trained primarily in the realm of forest management, I have always had a great admiration and respect for the pulp and paper industry. The mills of this giant industry are labor efficient, highly mechanized operations—somewhat in contrast to the other segments of our forest economy where labor expensive techniques have lingered and, in fact, remain in use altogether too widely to this day.

There are other impressions regarding the industry—some praise worthy and others not. But before I launch into these, I would like to mention a few facts about the mills in our state. Virtually all of state's pulp mills (and I believe I am correct in saying that most of these are pulp and paper mills of an integrated sort) are located in the northern region. They consume, in round numbers, a million cords of wood annually, and contribute substantially to the economic well-being of at least a dozen northern New York communities. VanOhlsen found that, in 1952, New York mills secured wood as follows: New York produced 39%; Canada, 37%; other states, mostly New England, 24%.

Neil J. Stout, Executive Director of the Joint Legislative Committee on Natural Resources of New York State, Albany, N. Y.

The mills, more specifically, are on rivers that flow out from the heavily forested Adirondack Mountains. Falls in the rivers serve as sources of electric power for the individual plants. And the water, flowing down from the great forest covered catchment area composed of granitic rocks and sterile sands, is pure and clean—virtually unsurpassed for use in the papermaking process. Originally the great bulk of the raw material requirements—principally red spruce—was floated down to the mills by these same streams. But this situation has changed as the result of the gradual depletion of the red spruce which once ranged over wide areas in the north country. Early cuts, removing only the spruce at first, but spruce and fir later, favored the hardwood succession so that the great mixed-wood forests of a century ago are now stocked with nearly pure hardwoods. The beech-birch-maple stands have thus taken over.

It must have been apparent to the farsighted men of the industry two or three decades ago, that the day would come when an inadequate supply of the choice pulpwood species—spruce—would be available. Mills were already bringing in raw materials from greater and greater distances—from Canada and the New England States. Intensive research sponsored by the industry itself, brought about the development of processes that made the use of hardwoods not only possible but economically profitable. We have another impression: A vigorous and progressive industry that recognizes the importance of research, the need for seeking new and better ways of doing things.

The fire reduction salvage on Forest Preserve lands following the November, 1950, hurricane kept a lot of mills in the spruce business for a few years longer. Thereafter, manufacturing processes were altered—plant by plant, mills were remodeled and equipped to turn out high-quality papers from the abundant hardwoods that grow in our forests. These mills responded in order to stay in operation. Heavy investments were required in many instances. Another impression: An industry flexible and responsive to change in terms of manufacturing process.

What about this change in raw material requirements? Let's think about it now from the forester's and timber-grower's point of view. Forest surveys completed within the last decade showed us that young stands of hardwoods (poletimber and smaller trees), containing from 6 to 12 cords per average acre, grow on approximately half of the land area in the northern zone. These lands are characterized by light, infertile soils, rugged topography, a severe climate, and generally heavy accumulation of snow late each winter. It follows that tree growth rates are rather slow, and the incidence of decay and climatically induced tree defects, such as frost cracks, is substantial and a troubling matter, indeed, to resource managers.

For years, forest managers had been plagued with the overabundance of low-value species such as beech and red maple, as well as with the crooked and defective stems of birch and sugar maple which lacked the potential of becoming prime sawlog and veneer log material. What was needed was a market for the lower quality wood so that it could be profitably removed to allow for the fuller development of high-quality timber crops. I well remember the proud proclamation by A. B. Rechnagel in September, 1947, at the summer meeting of the New York Section of the Society of American Foresters in Star Lake. At that time he was technical director of the St. Regis Paper Co. Having viewed stand after stand of young timber that contained so many poor trees, we all had our hopes bolstered when he boomed out, "Gentlemen, the era of hardwood pulping is just dawning!" This turned out to be true; but the implication that we might soon have the outlet for low-quality material—and a subsequent rehabilitation of our cut-over and beat-up forests—was a dream soon shattered. Instead of seeing only the crooked, low-quality trees move out of the stands, we have had to watch loggers, whose principal guide

was profit, select the best and *straightest* stems in the forest for cutting into pulpwood bolts. And it is understandable that mill managers, given the opportunity once more to be a bit selective about the shape, size, and quality of bolts arriving at the mill, and in view of the great new flood of wood available, were also happy to accept material that served them well in terms of cost of handling and processing, and I suppose also, with a certain increase in yields of fiber-per-cord.

To many, this further deterioration of our commercial forests has been a bitter disappointment. Admittedly, selective cutting (removing the lower quality trees from immature stands) costs more than the current popular commercial clearcut which takes everything *except* the too-small trees of those otherwise unsuitable. But what of the forests which are left? We're seeing a lot of sprout growth, definitely inferior to the seedling-origin tree. You know, there are stands composed almost entirely of multiple-stemmed trees. Ultimately, the practice is likely to leave us with little more than "brush."

A number of foresters—and I am among them—believe that there needs to be an incentive payment to the timber pulpwood. If the mills would pay an extra dollar or so per cord, when his stand was being cut judiciously under the supervision of a competent forester, we believe that more "forestry" would be practiced in the woods.

There have been other developments in recent decades in the acquisition of raw material that I am sure you are aware of. Happily, we have seen an increase in the conversion of sawmill waste (slabs and edgings) to chips for pulpmill use. For some pulpmills these chips constitute an important segment of the raw material requirements. The International Paper mill at Ticonderoga uses pine chips; hardwood chips are used by Black River Valley plants. If the pulp mills could pay a bit more for chips, the chip producers would consider the practice worth while.

The market for spruce has all but dried up, although I understand the Corinth mill of International Paper still buys some spruce. The West Virginia mill at Mechanicville is virtually a pure-hardwood operation, using 60,000 cords of rough green hardwoods per year—and the greener, the better, I am told. It is interesting to observe that company lands supply less and less of the total raw material. The West Virginia Co. owns very little land in New York State; other companies have been liquidating their holdings and buying wood—farmer and small timber tract wood. Increasing taxes may be responsible for the trend away from company-owned and company-managed lands. In the final analysis, I suspect the trend to be based on the well-founded opinion that pulpwood will be available for purchase of the open market. And certainly, with such evidence as the vast amounts of wood in the yards and the numbers of people contacting the mills almost daily this past fall and early winter wanting to sell pulpwood, this would appear to be true.

Let me make it clear, despite my earlier remarks, that several pulp and paper companies have an active forest management program. Outstanding are those of International, St. Regis, Diamond National, and Finch-Pruyn. Some companies are poisoning and deadening the standing timber, for bark removal and weight reduction. There is some product sorting where high-value sawlogs and veneer logs are sent off to the most appropriate markets. This is fine and should be encouraged.

Another recent development in the raw-material field has been the ever-increasing role of state-owned plantations in supplying cordwood to mills. This has been largely pine, used by the Diamond National mill at Ogdensburg and, I understand, experimentally by the St. Regis mill at Deferiet. Although the bulk of the large reforestation areas managed by the State Conservation Department are at a considerable distance from the mills of the North Country, the plantations around the fringe of the Adirondacks will undoubtedly provid more and more wood as time goes on. During the yea Oct. 1, 1959, to Sept. 30, 1960, nearly 3000 cords of pin plantation thinnings were sold by the State for pulpwood These are hopeful developments. Labor-saving technique are coming into the harvesting of pulpwood—mechanica loading, the use of racks in the woods, large circular cutof saws, etc., can be seen in use.

Now that I have indicated that, for the present, the pulp and paper industry has an abundance of the two principa raw materials, wood and water, what about the future?

It is my belief that the availability of pulpwood will continue good. As time goes on, however, there will be in al likelihood a substantial increase in the cost of procurement unless some changes are made in the manner of harvest There will be less harvestable material per acre, with a higher unit cost of harvest. As transportation distance increases, transfer costs will rise. On the plus side, are thousands of acres of planted timber which can provide more and more material for the industry. Also superior trees—the result of tree breeding—will be planted in the future. Any valid prediction regarding the future welfare of an industry should, of course, give consideration to many other factors. One of the most important is the market outlook, which seems particularly optimistic for New York pulp and paper mills. Proximity to a great number of users of fine printing and book papers (publishing houses) and nearness to over half of the population of the United States give the mills a genuine ad-vantage.

Our rapidly increasing population, expanding school enrollments, rising level of education, higher personal incomes, increased leisure, scientific and technological advances—all create new products and industries and increase the need for communication. All, individually and collectively, are widening the market for paper—books, periodicals and other printed materials.

What about water? This is a $64,000 question. The use of water by the pulp and paper industry—60,000 gal. to make a ton of paper—is regarded as nonconsumptive in character. However, the pollution problem will become more important as time goes on. Treatment and filtration of the water in order to make it potable and usable by downstream villages and industries will surely enter the picture. Also, greater attention must be given to instances where recreational uses are impaired through contamination by mill use. In short, our increasing population is placing unprecedented demands on the water resources of our state. Especially where the health and welfare of the public are involved, sources of high-quality water are a premium resource to be guarded even more rigorously.

Having sounded this note of caution, I want to emphasize now just how valuable the protection forests in our Adirondack region are in maintaining a steady flow of water in the rivers. Forest soils are spongey, and the many lakes in the Adirondacks serve as reservoirs, holding back the waters of melting snows and summer rains. Maintaining tree cover on the step lands retains the porous soil structure and reduces flash run-off.

I would now like to touch briefly upon the activities of the Pomeroy Committee. Although most directly related to the recreational potential of the remote, forested wilderness tracts in the mountains, to date, still these areas are of importance to the pulp and paper industry in safeguarding the steady flow of water.

Our committee set up preliminary standards for wilderness areas and went into the Adirondacks to begin an on-the-ground survey. The standard we set for a wilderness area was: minimum area of 10,000 acres with no habitations nor public or private roads. Other desired qualifications were that they lie beyond the sight, sounds, and odors of civilization; contain views of scenes of unusual interest; and instill

a feeling of adventure where full enjoyment depends upon a person's own perception, skill, and self-reliance.

During the summer of 1960, the field team was supplemented by two additional foresters who were acquainted with the Adirondacks and Catskills, and the survey was carried on in the two areas. With our standards in mind and with information gathered during 2 years of intensive field study, we delineated 12 regions in the Adirondacks and four in the Catskills which appear to offer the best opportunities as true wilderness areas. These comprise about one third of the Forest Preserve, and they alone possess the size required for a wilderness classification. Because the Forest Preserve belongs to the people, our next step will be to hold regional meetings and discuss our proposals with interested groups. Only after these meetings have offered full opportunity for expression of public views can we settle upon a suitable long-range plane. It will then be in order for the committee to recommend to the Conservation Department and to the Legislature, the steps necessary to put the plan to work.

After the Wilderness Areas are established, the committee will continue its long-range planning for other parts of the Forest Preserve. Some areas, for example, may possess qualifications of beauty or interest which would warrant special protection and a classification of their own, such as Wild Areas. Other sections, readily accessible to existing highways, might be suited for development of additional public campsites, picnic areas, or other types of intensive recreation.

In a talk at Glens Falls recently, Chairman Pomeroy gave vent to his personal philosophy regarding the Forest Preserve. Since the Joint Legislative Committee on Natural Resources of New York State is assisting in the long range planning for preserve use, you may be interested in just what he thinks.

1. The Preserve's most important use and its greatest benefit to the people lie in the opportunities it affords for outdoor recreation.

2. Its wilderness aspects are unique in the Eastern United States. Above all, they must be perpetuated.

3. Inasmuch as the Preserve belongs to all of the people of the State, the recreational wants of all must be considered. Along with the setting aside of areas devoted to wilderness, we must provide in other areas for the increasing public campsite needs and other such forms of outdoor recreation.

4. There should be no commercial exploration of the state's Preserve Forests. However, recognizing that research is important to any field for the development of sound programs, last year the committee sponsored legislation permitting the gift of lands in the Adirondack Park for the specific purpose of forest management and silvicultural research. The sooner this can be initiated, the better.

Presented at Feb. 3, 1961, meeting of Central District, Empire State Section TAPPI, held in Syracuse, N. Y.

Empire State (Metropolitan District)

It will take Soviet Russia at least 10 years to catch up with the United States in paper and pulp production but it has imported millions of dollars worth of machinery from Britain, Sweden, Finland, and Germany and is pushing hard to attain that goal.

This forecast was made by Albert W. Wilson, editor of the magazines *Pulp & Paper* and *Pulp & Paper International*, before the Metropolitan District, Technical Association of the Pulp and Paper Industry (TAPPI), March 14, in New York.

"The Communist countries think nothing of ordering two or three big machines at a time from a manufacturer," he said. "This has happened in Russia and Yugoslavia. In Poland, three big machines have gone into one new mill in less than a year. New machines from European plants are being built or have been built for Communist China, for Rumania, and other eastern countries."

Mr. Wilson has spent about 12 of the last 24 months in Europe, making a base on his last trip in Zurich. He has visited mills and talked to industry leaders in Russia, Poland, Finland, Sweden, Norway, Denmark, England, Scotland, France, Germany, Belgium, Holland, Switzerland, Italy, Austria, Spain, and Morocco.

"At any time Russia could be a disturbing factor on the wood pulp markets of the world, because of complete centralized control of its exports, but European paper mills expect to receive their major supplies for years to come from Scandinavia, first, and North America, second," he said.

"Many Europeans I have talked to, expect only a secondary filler-type of fiber supply from Russia this year and for the next few years. In England, France, and Germany they have brought Russian pulp in relatively small quantities. They regard it as of poorer quality but all right to mix with the quality cellulose from Scandinavia and America for some products. Actually, Sweden, the major supplier for the world, has not been able to produce enough unbleached sulfate this past year to meet demands from its normal customers, but it will catch up.

"The paper boom is still on in Europe, although there are some signs of slackening off. No one expects the mills to keep up the fantastic pace of the past year. Britain and France were making paper and paperboard at a rate 17% higher than the year before; other countries from 10 to 15% higher. This on top of lesser increases for several previous years.

"But Europe is still about 15 years behind the United States in packaging and it has a long way to go. With 600,000 tons or more of additional bleached kraft and soda base pulp coming into production between now and next January in four Canadian mills, the Scandinavia adding up to 2,000,000 tons in the next few years, Europe and countries elsewhere should have adequate supplies."

Russia is still making less than 4,000,000 tons of wood pulp and 4,000,000 tons of paper annually, less than half of Canada's output. The United States makes six times as much pulp and ten times as much paper. Though Russia is close to Sweden and Finland in pulp and close to Japan, Britain, and West Germany in paper, all of those countries showed a bigger gain last year than Russia, excepting for Britain. Russia's annual per capita consumption is only 32 lb. about the same as Mexico. It compares with over 400 lb. in United States.

In Moscow, Mr. Wilson recalled meeting Vlas Nitchkov, who sold wood- pulp and lumber from New York City offices from 1945 to 1948. In Moscow, he headed Exportles, the agency directing all exports of wood products, but lately, Mr. Wilson said, letters to Mr. Nitchkov have been answered by someone else and he doesn't know what happened to the former New York "pulp peddler." "He told me Russia's exports of wood pulp would remain at about 200,000 tons annually, more or less, mostly to the 'People's Democracies,' and he insisted Russia wants to convert most of its pulp to paper to raise the standards of its people," said the speaker.

"He insisted that Russia would continue to export substantial quantities of pulpwood to France, Germany, and other European countries for many years to come, despite the building of paper mills in Russia. He even predicted Russia would some day be shipping wood across the Pacific to the United States. But the French mill owners and others who have been dependent on Russia wood are uneasy and are afraid they will have to buy pulp or find other wood sources. This has stimulated the use of hardwoods in Europe."

Mr. Wilson said members of the Russian State Planning Commission told him of a huge plant they are building in the Ural Mountains region at Izhest, where they will make paper machines and all kinds of papermaking machinery. For pulp mills, equipment will be built at chemical equipment

plants. "Western Europeans selling machinery for pulp and paper mills are mostly resigned to the likelihood, as they say themselves, that after a few deliveries the Russians will duplicate the machinery in their own factories." said Mr. Wilson. "Some of these Europeans say the Russians, however, unlike other countries that copy equipment, will even improve on what they bought."

He said the Russians told him they will even make coated book or magazine paper on two new machines using what they called the Peter J. Massey process. This, of course, is the process invented by the late Mr. Massey of Chicago and on which Consolidated Water Power & Paper Co. held patents until recent expiration.

The Russians also are going to make considerable use of the fast growing reeds which are found in the broad river deltas of the Southern Russia and in the Danube delta, also.

In Leningrad, a group of Russian scientists showed Mr. Wilson a laboratory machine making electrical or special technical papers by what they called "the first dry process for paper." He said some dry processing has been done in America but abandoned as too expensive. Air-borne pulp is drawn down on a wire by vacuum to form the sheet, which then passes through a sizing bath of some sort, and then to driers, so even though no pure water is used, it is not exactly a "dry" process. The Russians said six "dry process" machines were going into commercial use.

Near Leningrad, Mr. Wilson visited a condenser paper mill with six machines, all exactly alike, the first two from Germany and the last two made in Leningrad. "It was a well run, clean mill, with many women working on machines and calender stacks—what we would regard as dangerous, hard jobs, and some were foremen. About 70% of employees were women. Average wage was 900 to 1000 roubles per month, but there was incentive payments, and good workers won other honors and had their pictures posted on large signboards at the mill entrance. The mill manager said they never had any strikes and that the mill made a good profit, presumably for the state."

In Poland, Mr. Wilson attended a pulp and paper conference where experts were brought from Britain, Germany, Sweden, Hungary, and Czechoslovakia to give lectures. He said it actually was a "school" for about 200 Polish engineers and technicians, who they wanted to train in a hurry to work in the new mills being built in that country. This was in Lodz, Poland's most important textile center—he said the Poles call it the "Polish Manchester." It is also Poland's only pulp and paper school and important research center, although there are no important pulp and paper mills in the region. Later he went by bus with international guests to Warsaw to visit with high government officials and then northward toward the Russian border where the new Ostolenka mill, now putting in its fourth machine, will be making 100,000 tons of kraft board and wrapping the bag paper. Each machine is 160 in. wide, built in England, and the first three were started last March, July, and October. It already makes one fourth of all the paper for Poland.

Mr. Wilson said he interviewed Jan Grudinski, a "dapper and talkative" little vice-minister of wood using industries, who told of plans to build even a bigger mill at Swicie, on the German border. Also a new kraft pulp and paper mill at Kostryn, near Germany, and a cellulose mill near Stettin. Berlin, he said, would be a market for Polish pulp and paper.

A few Russians were at the conference and made the mill trip in Poland, and the Poles were very solicitous of them and anxious to honor them in every way possible as special guests, said Mr. Wilson. Many speeches were translated into Russian, even though there were so few of them present.

"Poland is a very poor country, despite the huge investment in paper and pulp, and I found that generally paper industry executives had no cars of their own, lived frugally in old apartments, and generally were not as well off as their opposite numbers in Russia. But in both countries they are making personal sacrifices, as they said, to lift the country to greater heights as paper and pulp producers. Even men with high positions in plants and institutes go without many things Americans would consider as necessities. High government officials, however, appeared to be wealthier.

"Individually and as a group, the paper and pulp people in both countries were very friendly and outgoing; doing everything they could, especially in Poland, to make visitors welcome. They were very pleased to be able to exchange information and make friends with Westerners.

"There was also quite an independent streak in the Poles, who are usually flying their red and white Polish flag above the Communist flag, and often you see the Polish flag alone. They point out they have three different political parties, though they are not much different actually—but this is unique for a Communist nation. Only a minority, even in Poland, are Communist Party members but there are over 90% Catholics. They have paradoxical terms for some people—for instance, I was told 'we have a lot of Catholic atheists,' whatever that may be. At any rate, the Poles cherish their love for arguing over matters of soul and spirit, and the Russians apparently have decided to not interfere, as long as it seems rather harmless."

Of other countries, Mr. Wilson said:

"The Germans are the most aggressive; their progress in cellulose and paper has been with emphasis on production rather than quality, so far.

"The French are characteristically suited for technical studies and have done much good scientific work, but their companies have been ultraconservative. Lately, to realize the broader opportunities in the Common Market, there has been a wave of mergers in French pulp and paper companies.

"The British, at least in some companies, are perhaps the best in the world technically in paper. It is expanding in many other countries.

"The Scandinavians are pushed ahead with pulp production, but they can change some of their plans and make paper or board—instead of so much pulp for market, if world conditions indicate that's desirable. More and more Scandinavian mills are using birch for pulp, and this has greatly added to the potential forest resources.

"In the areas around Switzerland—south Germany, southeast France, north Italy and Austria—pulp will be made in greater quantities from poplar but to meet their needs they must still import considerable wood pulp.

"Linerboard is finding a big market in Europe, with America competing with Finland and Sweden to supply needs. This results from the increase in demand for fiber boxes. Packaging papers, the superior tissue products developed in America, and some printing papers are in strong demand in Europe. Several American companies, as well as British, have joined with European Continental companies to manufacture tissue, containers, etc., within the Common Market. They have chosen as partners, outstanding companies in France, Germany, Belgium, Holland, and Italy, which already have a strong sales force and good contacts with governments, etc.," said Mr. Wilson.

Another important trend abroad is to build plants to make cellulose from rye, wheat, and other straws—these to extend to cellulose fiber supply for countries which lack sufficient pulp resources. Mr. Wilson said new straw pulp mills have recently been built or are being built in France, Italy, Hungary, Jugoslavia, Germany, Denmark, and Egypt.

Tenth Statistics Course

Queens University

Kingston, Ont.

June 19–30, 1961

Analysis of Sulfite Cooking Liquors

John Morris

An analytical method applicable to neutral sulfite semichemical liquor and to sulfite cooking acid has been developed. There is no change in the usual way of determining sulfite or total sulfur dioxide, but in the determination of alkalinity or free sulfur dioxide a procedure dependent upon the reaction between iodate, iodide, and hydrogen ion is used. The method described is shorter than other methods and requires fewer standard solutions. There is no loss in accuracy.

CURRENTLY used methods (*1*, *2*) of analyzing neutral sulfite semichemical cooking liquor and sulfite cooking acid determine the reducing agents present and the alkalinity or acidity of the liquor. In NSSC liquor the reducing agents are expressed as grams per liter of sodium sulfite and the alkalinity is expressed as grams per liter of sodium carbonate (*3*) or bicarbonate (*1*). In sulfite cooking acid the reducing agents are expressed as grams per 100 ml. of total SO_2 and the acidity of the liquor is expressed as grams per 100 ml. of free SO_2 (*2*). The method described here analyzes for the same two things as other methods, the reducing agents present and the alkalinity or acidity of the liquor. In analyzing for reducing agents the method is the same as other methods. In determining the alkalinity or acidity of the liquor, however, an iodometric method is substituted for the usual acid-base titration. The procedure described is shorter than others and requires fewer standard solutions. There is no loss in accuracy.

APPARATUS AND REAGENTS

The apparatus needed is as follows: one 5-ml. pipet, one 50-ml. pipet, one 100-ml. pipet, two 50-ml. burets, one 25-ml. graduated cylinder, one 500-ml. Erlenmeyer flask.

The following reagents are required: standard 0.1 *N* I solution approximately 0.3 *N* in KI, standard 0.1 *N* Na_2SO_3 solution, approximately 1 *N* KI solution, starch indicator.

PROCEDURE

1. Pipet 100 ml. of 0.1 *N* I solution into a 500-ml. Erlenmeyer flask. The volume of 0.1 *N* I used in this step is designated A.
2. Pipet in 5 ml. of the liquor to be analyzed holding the tip of the pipet at the surface of the iodine solution so as to avoid air oxidation.
3. Back titrate with 0.1 *N* $Na_2S_2O_3$ solution adding starch indicator, just before the end point. This volume of thiosulfate is designated B.
4. If carbonates are present, boil and cool the solution.
5. Add approximately 20 ml. of 1 *N* KI.
6. Pipet in 50 ml. of 0.1 *N* $Na_2S_2O_3$ solution. This volume of thiosulfate is designated C.
7. Back titrate with 0.1 *N* I solution. This volume of iodine is designated D.

CALCULATIONS

For neutral sulfite semichemical liquors

$$\text{Grams of } Na_2SO_3 = 0.0063\ (A - B)$$

$$\text{Grams of } Na_2CO_3 = 0.0052\ \{(A - B) - (C - D)\}$$

For sulfite cooking acid

$$\text{Total } SO_2, \text{ grams} = 0.0032\ (A - B)$$

$$\text{Free } SO_2, \text{ grams} = 0.0032\ \{(C - D) - (A - B)\}$$

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DISCUSSION

The first three steps of the above procedure are like other methods of determining reducing agents. Sulfite reacts with iodine to produce sulfate and hydrogen ion (4).

$$SO_3^= + I_2 + H_2O \rightarrow SO_4^= + 2I^- + 2H^+ \qquad (1)$$

The excess iodine is back titrated with thiosulfate.

$$2S_2O_3^= + I_2 \rightarrow S_4O_6^= + 2I^- \qquad (2)$$

The sulfite in the sample is equivalent to the iodine it consumes and this is (A − B).

(A − B) times a factor gives the amount of sodium sulfite present or the total SO_2.

The rest of the procedure depends upon the hydrogen ion produced in reaction (I). This reaction produces an amount of hydrogen ion equivalent to the sulfite present and so also equivalent to (A − B). This acid is usually sufficient to insure that the solution remaining after step 3 is acidic. If it is not, a measured amount of acid must be added at the beginning of the procedure.

The solution is boiled to remove carbon dioxide and cooled. The acid present is then determined by adding an excess of potassium iodate. There is already present in the solution an excess of potassium iodide which was added in the iodine solution. Reaction (3) takes place.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + H_2O \qquad (3)$$

Since iodate and iodide are both present in excess, the reaction produces an amount of iodine equivalent to the hydrogen ion present (*5*). It is not possible to titrate the liberated iodine directly with thiosulfate because starch is already present. Instead an excess of thiosulfate, C, is added and the remainder, D, back titrated with iodine. The difference (C − D) represents the liberated iodine and therefore is equivalent to the acid present.

In general (A − B) the amount of acid effectively added to the sample by reaction (II) and the acid actually found (C − D) are not the same. In the case of NSSC liquors (C − D) is less than (A − B) because the sample was originally alkaline, and the difference (A − B) − (C − D) measures the alkalinity originally present. Therefore, (A − B) − (C − D) times a factor gives the alkalinity of the sample expressed as grams of Na_2CO_3. In the case of sulfite cooking acid (C − D) is greater than (A − B) and the difference (C − D) − (A − B) measures the acidity originally present in the sample. Therefore, (C − D) − (A − B) times a factor gives the acidity of the sample expressed as grams of free sulfur dioxide.

The method depends upon the liberation in reaction (1) of an amount of hydrogen ion equivalent to the reducing agents present. Therefore, reducing agents which do not liberate equivalent hydrogen ion when oxidized by iodine interfere.

Table I. Analysis of Pink Liquor

	Sodium sulfite, grams				
Trial	*In Sample*	*Added*	*Total*	*Found*	*Error*
1	0.5553	0.2456	0.8009	0.8002	0.0007
2	0.5569	0.2450	0.8019	0.8006	0.0013
3	0.5562	0.2446	0.8008	0.7997	0.0011
	Sodium carboate, grams				
Trial	*In Sample*	*Added*	*Total*	*Found*	*Error*
1	0.2364	0.3138	0.5502	0.5508	0.0006
2	0.2362	0.3138	0.5500	0.5514	0.0014
3	0.2367	0.3138	0.5505	0.5496	0.0009

EVALUATION

Evaluation of the method for accuracy in analyzing neutral sulfite semichemical liquors was made using industrial pink liquor. A 5-ml. sample of the pink liquor was analyzed by the method described. At the same time to a second 5-ml.

sample was added an exact amount of a standardized sodium carbonate solution and an exact amount of a standardized sodium sulfite solution. The second sample of pink liquor with the additions was immediately analyzed in the same way. Results are shown in Table I.

The errors are approximately 0.5% based on the pink liquor before additions. When results are expressed on a gram per liter basis the errors are of the order of 0.2 g.p.l.

In analyzing NSSC brown liquor results are less accurate because of interaction between iodine and organic materials

Table II. Analysis of Brown Liquor

Trial	Sodium sulfite, grams				
	In Sample	*Added*	*Total*	*Found*	*Error*
1	0.0056	0.2101	0.2157	0.2132	0.0025
2	0.0052	0.2142	0.2194	0.2174	0.0020
Trial	**Sodium carbonate, grams**				
	In Sample	*Added*	*Total*	*Found*	*Error*
1	0.0147	0.1538	0.1685	0.1636	0.0049
2	0.0152	0.1538	0.1690	0.1650	0.0040

present. For this reason a slightly modified procedure has used. Since the interference appears less in acid solutions, 40 ml. of 0.1 *N* HCl was added by pipet at the beginning of the procedure and was, of course, accounted for in the calculations. To minimize both air oxidation of sulfite and contact between iodine and organic materials, 100 ml. of iodine was not pipetted into the flask and the excess back titrated as prescribed in steps 1, 2, and 3. Instead slightly less than the amount of iodine required was run into the flask from a buret. The sample was pipetted into this, starch was added, and the titration was then continued with iodine to the end point. Evaluation was made using industrial brown liquor. A 5-ml. sample of the brown liquor was analyzed as described. At the same time to a second 5-ml. sample was added an exact amount of a standardized sodium carbonate solution and an exact amount of a standardized sodium sulfite solution. The second sample of brown liquor with the additions was immediately analyzed in the same way. Results are shown in Table II.

The errors are considerably greater than the errors in the pink liquor determinations. On a gram per liter basis the errors in the pink liquor determinations. On a gram per liter basis the errors amount to about 1 g. Na_2CO_3 per liter of brown liquor.

Evaluation of the method for accuracy in analyzing sulfite cooking acid was made by comparison with TAPPI Standard

Table III. Analysis of Sulfite Cooking Acid

Trial	*Total SO_2, g./100 ml.*	*Free SO_2, g./100 ml.*		*Difference*	
		T 604	*Method described*	*g/100 ml.*	*%*
1	6.003	4.626	4.711	+0.085	1.8
2	5.956	4.590	4.645	+0.055	1.2
3	5.939	4.560	4.643	+0.083	1.8
4	5.918	4.540	4.600	+0.060	1.3

T 604 m-45. A cooking acid was made up by bubbling sulfur dioxide gas through a slurry made by adding 15 g. MgO and 18 CaO to 3 l. of water. This acid was analyzed by both methods. The procedure given was modified slightly because of the greater proportion of acid. The original cooking acid was diluted 10 to 1 as described in T 604 and a 15-ml. aliquot of this was analyzed. The amount of 0.1 *N* I used in the step 1 was reduced from 100 ml. to 50 ml. The solution was not boiled. No other changes were made. Since determination of total sulfur dioxide is the same in both methods only comparisons of the results of determinations of free sulfur dioxide are made. These are given in Table III.

Determinations of free sulfur dioxide by the method described were about 1.5% higher than determinations by T 604. An explanation of this lies in the incomplete conversion of bisulfite into sulfite at the phenolphthalein end point. The ionization constant for the reaction

$$HSO_3^- = SO_3^- + H^+$$

is 6.2×10^{-8} (*6*). From this the percentages of bisulfite present in sulfite-bisulfite mixtures at various pH values have been calculated and are plotted in Fig. 1. Also shown are the pH ranges over which the indicators phenolphthalein

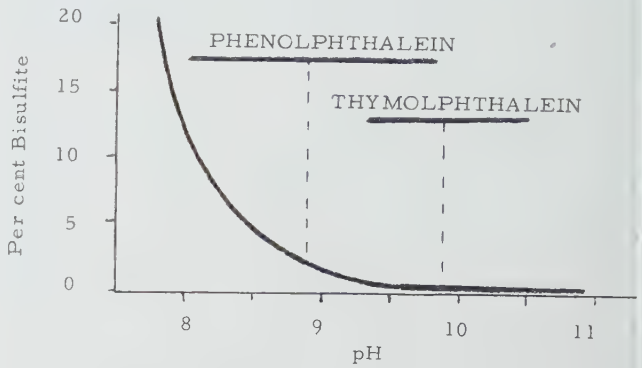

Fig. 1. Per cent bisulfite in sulfite-bisulfite mixtures

and thymolphthalein change color. At the midpoint of the range of phenolphthalein there is about 2% bisulfite present. When titrating with sodium hydroxide to the phenolphthalein end point as prescribed in T 604 some bisulfite remains unconverted to sulfite. This causes results to be low. Further evidence is found by substituting thymolphthalein for phenolphthalein in the T 604 procedure. Results with thymolphthalein were 5% higher than with phenolphthalein. Since the results of T 604 tend to be low, the 1.5% difference between the method described and T 604 is favorable.

SUMMARY

A method of analyzing neutral sulfite semichemical cooking liquors and sulfite cooking acids is described. The method described is shorter than currently used methods and requires fewer standard solutions. When applied to NSSC pink liquor results are accurate to within 0.5% the error being approximately 0.2 g. Na_2CO_3 per liter. When applied to NSSC brown liquor results are somewhat less accurate because of interference by organic materials, the error being approximately 1 g. Na_2CO_3 per liter. In analyzing sulfite cooking acids the free sulfur dioxide determined by the method described was approximately 1.5% higher than the free sulfur dioxide determined by TAPPI Standard T 604. The difference is due to incomplete conversion of bisulfite to sulfite at the phenolphthalein end point which causes results from T 604 to be low.

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Linear Programming and the Paper Industry

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Linear programming is a new mathematical technique developed in the post-war years which can be applied to certain problems in the paper industry. These problem areas are the trim problem, machine assignment problem, product distribution, and pulpwood procurement. Linear programming can assist management in the decision-making realms of scheduling, standards, and forward planning to aid in minimizing costs and maximizing profits. Concurrent computer developments will permit linear programming to be applied in the paper industry during the 1960's. Linear programming models of the four problem areas are described in the appendix.

An examination of the literature on linear programming will show that the majority of this material was published after 1950. Linear programming was probably first used operationally during World War II to solve problems of military significance. Very little knowledge of these military applications has been made available, and for a short time between the end of the war and 1950, very little was mentioned or written about linear programming.

However, many of the scientists who worked with linear programming during the war returned to the universities and the business world and began to investigate the theoretical and practical aspects of the techniques which had been in use during the war. The mathematicians have been fascinated with linear programming because of the fact that it is possible to produce a unique solution to a set of linear programming equations. This fascination is also engendered by the complex matrix manipulations and multidimensional vector spaces associated with linear programming.

In spite of the extensive literature on linear programming, the emphasis has been to a large extent on technique and mathematics with lesser emphasis on practical application. The emphasis of this paper will be on the application of linear programming to the paper industry; the mathematical models will be found in the Appendix.

I shall define linear programming simply as the economical allocation of physical resources to demands to minimize the costs or to maximize the profits of allocation. In most nontrivial allocation problems, the various possible combinations which must be considered render these problems difficult to resolve using the conventional tools of experience, judgment and intuition. Fortunately, the mathematics of linear programming renders an optimal solution beyond which improvement is impossible without changing the formulation of the problem. The optimal solution can provide management with a benchmark against which to compare actual performance. The optimal solution achieves the best allocation of resources to demands in an operation to ensure the most economical use of such resources. Also, the optimal solution and the ability to describe mathematically various physical and operational restrictions on resources provides management with a valuable tool to use in forward planning.

This paper will attempt to show how linear programming can assist management in these three aspects of decision making: operations, planning, and standards. Four problem areas within the paper industry, which can be described mathematically by linear programming equations, will be described and some of the difficulties which may arise in the implementation of linear programming solutions will be discussed.

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THE TRIM PROBLEM

The trim problem is one of scheduling the slitter blades at the paper machine rewinder in such a way as to cut out the required number of rolls from a succession of sets while minimizing trim loss. This is an old problem and only within the past five years has a new technique evolved for solving this problem. However, there are numerous restrictions on the use of linear programming to reduce trim loss and this paper will attempt to outline the advantages and disadvantages of using linear programming to reduce trim loss. A description of the slitting process will be of interest at this point in order to aid in the further description of the variables with which we are concerned.

Paper comes of the paper machine on log reels which are then rewound at the rewinder. As the paper is rewound, it is slit so that a number of rolls are being rewound at the same time. These rolls, along with trim at the side, comprise a set. After the set has reached a prescribed diameter, a new set is begun, and the rolls in the old set are separated for further processing. The rolls may be identified and wrapped for shipment to customers or they may be sent to the cutters (as may be the case for printing papers) for eventual cutting and trimming.

The schedulers use their experience, judgment, and intuition in order to "trim out" the rewinder and may come close to keeping trim loss to a minimum. But the extreme number of combinations which can arise from a relatively small number of roll widths is indicative that there is always some chance of further reducing trim loss.

The linear programming solution for the trim problem has been programmed for high-speed computers. The calculations involved in the solution are so time consuming that manual solutions are not feasible. The size of the mathematical matrix and the great number of calculations necessitate high-speed large-storage devices in many cases. If the problem formulation can be simplified through suitable approximations, medium sized computers could be used. The specific nature of the trim problem as it occurs will determine the type of computer needed to perform the calculations.

Following is a list of factors which should be considered in an investigation of the trim problem and its linear programming computer solution:

1. The diameter, core size, grade, and basis weight of the rolls which are to be cut according to a linear programming schedule must be identical.

2. For certain grades and basis weights, customers order rolls and sheets, and the two are manufactured during the same machine run. The sheet orders may be manufactured in rolls of any diameter which will fit the backstands of the cutters. As far as linear programming is concerned, sheet orders may be scheduled between more than one roll diameter—the greater the number of diameters, the greater the opportunity to reduce trim. However, as the number of diameters into which the sheet orders combine increases, the size of the mathematical problem on the computer (and thus computer time and cost) increases. Experience has shown

that sheet orders should not be combined among more than two roll diameters and preferably should remain in one roll diameter.

3. A quick check, to determine whether a computer solution would *not* be necessary, may be made by looking at the deckle-width ratio. This whole number is found by dividing the maximum usable machine deckle by the various roll widths which are to be cut. If these ratios are all similar, then no means of combining widths will result in an overall reduction of trim loss.

4. Use of linear programming should reduce trim loss by 30%. Since actual trim losses can be determined through examination of historical data, an estimate of potential savings can be made through the use of a rule of thumb:

(tonnage of run) × (% historical trim loss) × (30%) × (value per ton) > (total linear programming costs)

5. Since linear programming considers many more combinations in scheduling than the human scheduler, it is to be expected that more slitter changes on the rewinder will result. In some instances, the additional number of changes may be crucial depending on the efficiency of the rewinder relative to the speed of production on the paper machine.

6. Transforming raw production data into suitable form for keypunch operators and transcribing computer solutions into practical production guides comprise the clerical labors. Since the trim problem has been programmed for a number of computers, the running of the problem on the computer can be handled by tabulating personnel. Thus, the day-to-day usage of linear programming will not tie-up high-paid personnel.

7. Given a group of customers orders; that is, requirements for rolls of various widths which are to be manufactured during a run of a certain grade and basis weight of paper and cut from sets of the same diameter with cores of the same diameter, the computer solution combines roll widths in an optimum manner completely neglecting such factors as shipping dates, available transportation, or temporary storage facilities. The computer determines the various combinations to be cut and the number of sets of each combination to supply the required number of rolls. The computer will not determine the proper sequence of the sets. Thus, it is conceivable that a customer might have some of his requirements manufactured early in the run and the rest of his requirements at the end of the run. This necessitates sufficient storage space either in the mill or in a truck or rail car. In some cases, the restrictions placed on free combinations by these factors could so reduce the amount of combination to make computer solutions infeasible.

8. Given information concerning customer requirements for a given machine run, the linear programming schedule can be produced. However, if customer requirements change or production difficulties are encountered after the linear programming schedule has been produced, a new schedule may have to be produced because the old schedule may not be applicable under conditions. Because a single customer's requirements will be manufactured concurrently with other customers' requirements, a cancellation or alteration in his requirements will change the structure of the linear programming problem. When parts of sets are rejected, requirements for the balance of the production run change and a new linear programming solution should be generated. Obviously to take changing conditions into consideration, the time lag between the discovery of the changed conditions and receipt of the new solution becomes quite important.

Access to the computer becomes quite important if there are many changes either in customer requirements or in operating conditions. Inventory runs offer the best field for experimentation with linear programming because requirements do not change radically.

When manufacturing for inventory, it is possible to set up inventory requirements in such a way as to cut trim loss to an absolute minimum, if there is sufficient slack in inventory requirements to prescribe minimum and maximum tonnage.

9. The linear programming solution will find the optimum combinations, but the solution will direct that a *fractional* number of sets be manufactured. The mathematical solution can be rounded off and the number of rolls of each requirement to be manufactured will usually fall within the commercial tolerance. Only where a customer's requirements are quite small will the rounding error bring about possible difficulties.

These factors should provide some insight into the problem of applying linear programming to the trim problem. Besides applying the linear programming technique to actual production and inventory runs, there are other uses for this technique.

Standards. It might be of interest to measure the effectiveness of the present manual scheduling and to establish standards against which the scheduler's performance could be compared. Periodic linear programming solutions would determine the minimal trim loss possible. This would provide a measure against which to compare day-to-day manual scheduling. In addition, the periodic solutions could provide mill personnel with the basic information needed to determine whether operational use of linear programming were feasible.

Planning. When constructing a new paper machine, management is concerned with the width specifications for the new machine. If the distribution of tonnage among the various roll widths is known, linear programming calculations could assist in determining the best width or widths of the machine.

MACHINE LOADING PROBLEM

The machine loading problem has not had so much publicity as the trim problem, but there are probably greater potential savings to be found in this area. Given a number of paper machines and given a certain amount of tonnage of different grades to be manufactured, it is possible to allocate the required tonnage to the paper machines in such a way as to minimize the manufacturing cost or to maximize the profit. As in the solution to the trim problem, the linear programming solutions to the machine assignment problem provide an optimal allocation of grades to machines.

The mathematical computations involved in the solution are not so cumbersome as in the trim problem and a medium size computer can handle them. With suitable approximation, hand solutions by clerical personnel could be worked out using the modified index method.

The information necessary to formulate the linear programming equations is:

1. Tonnage of each grade to be manufactured
2. Machine capabilities in each grade in hours per ton
3. Direct cost per ton for each grade on each machine, or
4. Direct profit per ton for each grade on each machine
5. Available machine hours

The successful application of such a technique is dependent on the flexibility of the papermaking operations themselves. In time, each machine seems to acquire a preference for certain grades of paper. These preferences are a result of conscious or unconscious specialization and may well result from some accidential good fortune in some period in the past in running certain grades.

At any rate, the machine crews prefer some grades over others and, in time, the various paper machines become more and more experienced in running a smaller and smaller number of grades. The mill gains specialized proficiency at the risk of losing flexibility. In time, this seriously limits the number of choice of shifting grades from machine to machine. The more limited the number of choices, of course, the less that can be done from a mathematical point of view.

Another limiting factor concerning the use of linear programming is the flexibility of the organization itself. If production and information control are good, then a mill could shift grades from machine to machine, as a linear program solution might direct, with a minimum of confusion. Unless the control were present, use of a sophisticated scheduling technique affecting production on most or all of the machines in a paper mill would only confuse personnel, disrupt production, and set management science back indefinitely.

Management can apply linear programming to the machine assignment problem in the three areas of production scheduling, standards, and planning.

Production Scheduling. Given a forecast or actual knowledge of the amount of paper by grade to be manufactured during a certain period (such as one month, half-month, etc.) the linear programming solution would direct the optimal distribution of grades to machines. Such a schedule would not show the proper manufacturing sequence to be maintained; but the sequencing could be obtained manually after the computer allocation. The allocation would have to be updated as frequently as is necessary to comply with changing sales requirements.

Standards. Before it is decided whether to attempt the use of linear programming, it is necessary to compare historical production records with what a linear programming schedule would have produced. Such a comparison will provide a measure of the magnitude of improvement that linear programming could bring about.

This technique could provide insight into the historical specialization pattern of the paper machines. It might well be that many of the grades presently being manufactured are being run on the wrong machines. In fact, the cost picture might be quite sensitive to the allocation of grades to machines; and in allocation problems such as these, no one knows how well a function such as scheduling is being performed, unless he has some absolute yardstick against which to compare.

Planning. In building a new paper machine, or rebuilding an old one, management would like to know what effect the new machine will have on the profitability of the mill as a whole. If there were sufficient interchangeability of grades among machines, management could use linear programming to see how the various grades might re-establish themselves under the changed production conditions brought about by the new machine.

Furthermore, management could rebuild or construct a machine using specifications derived from testing through linear programming for the type of new capacity needed to increase profits for the mill as a whole. In both of these situations, the information needed is a forecast of tonnage expected to be ordered by grade, productivity of all machines in hours per ton, the direct profit for each grade on each machine, and the forecast of available machine hours.

PRODUCT DISTRIBUTION

As the paper industry extends its marketing effort toward the ultimate consumer of its products, either through the acquisition of converting and printing plants or through the manufacturing of consumer products, such as the present sanitary papers market and the future nonwoven fabric field, it should be worthwhile for management to be aware of the use of linear programming in the product distribution area.

The classic title for this technique is the transportation problem in which the problem is to determine, among a number of factories and a number of warehouses, the amount of product to be shipped from each factory to each warehouse. Many national firms have applied linear programming to their distribution problems and have realized significant savings from doing so. In the paper industry, the transportation problem may be applied where there are a number of mills scattered throughout the country which ship products to warehouses or trans-shipment points throughout the country, or ship to converting or printing plants throughout the country. As in the trim problem and the machine loading problem, standards could be devised through linear programming to test the efficiency of the conventional distribution scheduling process.

Utilization of this new technique for planning purposes occupies a prominent place in the product distribution problem. For example, given a multiplant, multiwarehouse distribution system, management may be interested in determining where to increase production capacities. Armed with forecasts of future demand, a knowledge of the variable manufacturing costs at each manufacturing location, and the variable transportation costs, experimentation with a linear programming model would show where the extra capacity should be installed to minimize overall distribution and manufacturing costs. By considering the many alternatives and the total costs associated with each alternative, management could reach a logical decision based on quantitative information. This type of analysis is feasible for small-scale expansion such as the installation of a single cutter or trimmer as well as large scale expansion in the form of a new paper machine.

Perhaps the most valuable use of this technique would arise in the event of a national emergency, in which the Government, in implementing a national distribution policy, could direct the distribution of product between mill, converter, and consumer in such a way as to minimize transportation cost, time in transit, or some other variable of importance to the Government. In fact, the Russian Government has been taking a national inventory of its productive capacities and according to Harry Schwartz of the *New York Times*, the planners of the Soviet Union are attempting to distribute their goods through the use of linear programming. It is possible to speculate that the Soviet paper industry would participate in this scheme.

PULPWOOD PROCUREMENT

The pulpwood procurement field offers an interesting opportunity to investigate the use of linear programming in minimizing wood procurement costs.

Pulp mills depend on surrounding geographical areas for their pulpwood requirements and many mills utilize collection yards in their procurement efforts. The collection yards consist of cleared areas with wood handling equipment and rail loading and truck unloading facilities. The pulpwood producer brings in cordwood to the collection yard where it is unloaded and stacked to await shipment to the mill by rail. Procurement costs include the purchase price, handling costs, storage costs (which comprise wastage, money charges, rot, etc). and transportation costs to the mill

Pulpwood availability varies from season to season and from area to area. This variability is caused by the natural distribution of tree species, weather conditions which inhibit wood gathering and competing demands on the pulpwood producer (such as agriculture). Policy decisions influence the purchases of pulpwood; for example, management attempts to purchase no less wood than a certain minimum at various collection yards in order to maintain interest in those locales on the part of the producers. In spite of these restrictions, there exists a wide area of decision-making in determining how much to purchase and when and where to inventory.

All of these restrictions can be formulated mathematically in the linear programming model, and a linear programming solution would direct how much wood should be purchased at each collection yard during each time period. The solution would also direct where to establish inventories and determine the size of the inventories.

In addition to providing standards for evaluation of present procurement costs, the linear programming technique also allows management to gage the effect of policy decisions on the total procurement costs. Through manipulation of the model, management could test the various policies such as those concerning minimum purchase requirements and could arrive at quantitative estimates of the costs of maintaining the policies.

Also, the overall effects of adding new collection yards to the system could be evaluated scientifically: from a number of alternate yard sites, the best one could be picked by testing systematically through linear programming to determine which site would yield the lowest procurement costs for the system as a whole.

Probably the most serious barrier against the use of linear programming in the paper industry is the computational difficulty brought about by matrix mathematics. In fact, the recent development of digital computers has been quite instrumental in sparking investigations of linear programming applications since manual calculations have proved to be impractical in most cases. The advent of competition in the digital computer field has brought computer prices down recently; and future computer developments brought about by both increased competition and governmental expenditures on research and development in the computer and allied fields promises to provide industry with computers of higher speed and greater capacities at quite reasonable prices.

Viewing linear programming in perspective and realizing that it is a new technique dependent on computer development, I believe that one might say that the decade of the 1950's was one during which linear programming was developed and the decade of the sixties will be one in which linear programming will be used.

APPENDIX

Linear Programming Model of the Trim Problem

Let the subscript j refer to each combination of roll widths possible in a set. The subscript i will refer to each roll width. Then,

a_{ij} = the number of widths i to be cut from combination j.
b_i = the number of rolls of width i which are required to be manufactured.
c_j = trim loss associated with the j-th combination.
x_j = the number of sets of combination j which are to be cut for minimum trim loss. This is the unknown which is to be determined through linear programming.

The restrictions are:

$$\sum_{j=1}^{n} a_{ij}x_j = b_i \; (i = 1,2,\ldots, m)$$

This expression indicates that no matter which combinations are to be cut, no more and no less than the required number of rolls are to be made.

Alternate restrictions might be:

$$\sum_{j=1}^{n} a_{ij}x_j \leq U_i \quad (i = 1,2, \ldots, m)$$

$$\sum_{j=1}^{n} a_{ij}x_j \geq L_i \quad (i = 1,2, \ldots, m)$$

These alternate restrictions allow slack in the requirements. U_i becomes the upper limit on the number of rolls of width i to be made and L_i becomes the lower limit on the number of rolls of width i. The computer can then seek out a better solution than could be obtained from a rigid restriction on the number of rolls to be made.

The objective function is the function to be minimized.

$$\sum_{j=1}^{n} c_j x_j = \text{minimum}$$

Programs for the larger computers automatically find all the various combinations of roll widths.

Linear Programming Model for the Machine Loading Problem

Let the subscript i refer to the grade of paper to be manufactured and let subscript j refer to the paper machine. Then,

a_{ij} = hours per ton manufacturing time when grade i is running on machine j.
b_j = time available on the j-th machine, in hours.
d_i = number of tons of grade i which must be manufactured.
c_{ij} = the variable cost per ton of running the i-th grade on the j-th machine.
x_{ij} = the number of tons of the i-th grade which will be manufactured on the j-th machine. This is the unknown which is to be determined.

Restrictions on the amount of paper which can be produced on any machine due to the time available is formulated as follows:

$$\sum_{i=1}^{m} a_{ij}x_{ij} \leq b_j \quad (j = 1,2, \ldots, n)$$

Restrictions on the number of tons to be made of each grade are:

$$\sum_{j=1}^{n} x_{ij} = d_i \quad (i = 1,2, \ldots, m)$$

And the objective function is:

$$\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij} = \text{minimum}$$

Linear Programming Model for Product Distribution

Let the subscript i indicate the mill of origin and the subscript j indicate the plant to which the goods are to be shipped.

a_i = the capacities of the i-th mill.
b_j = the demands of the j-th plant.
c_{ij} = the unit cost of shipping from mill i to plant j.
x_{ij} = the amount to be shipped from mill i to plant j. This unknown is to be determined.

Restrictions on how much can be shipped from each mill are:

$$\sum_{j=1}^{n} x_{ij} \leq a_i \quad (i = 1,2, \ldots, m)$$

Restrictions on how much can be shipped to each plant are

$$\sum_{i=1}^{m} x_{ij} = b_j \quad (j = 1,2, \ldots, n)$$

The objective function is:

$$\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij} = \text{minimum}$$

Linear Programming Model for Pulpwood Procurement

A *suggested* formulation for this problem is as follows:

Let x_{ijk} be the amount of wood to be purchased during time period i which is to be shipped to the mill during time period j from collection yard k. Thus subscript i is reserved for the purchase period, subscript j is reserved for the shipping period and subscript k indicates the collection yard.

a_j = the requirements at the mill during the j-th period.
b_{ik} = amounts which *must* be purchased during the i-th period from the k-th collection yard.

c_{ijk} = the unit cost of acquiring wood during the i-th period and shipping during the j-th period from the k-th yard.

d_{jk} = the maximum capacity at the k-th yard during the j-th period.

The restrictions which describe the amounts of wood which must be delivered to the mill during each period are:

$$\sum_{i=1}^{p} \sum_{k=1}^{p} x_{ijk} = a_j \quad (j = 1,2, \ldots, n)$$

Restrictions on the minimum amounts to be purchased from selected yards at selected periods are:

$$\sum_{j=1}^{n} x_{ijk} \geq b_{ik} \quad (i = 1,2, \ldots, m), (k = 1,2, \ldots, p)$$

Restrictions on how much can be stored at the yards at any one time are:

$$\sum_{i=1}^{m} x_{ijk} \leq d_{jk} \quad (j = 1,2, \ldots, n), (k = 1,2, \ldots, p)$$

Restrictions of a mathematical nature must be included to insure that the solution does not prescribe that wood be purchased at a future period to be shipped during a prior period.

$$c_{ijk} = M \ (i > j) \quad \text{where } M \text{ is a prohibitive cost.}$$

The objective function is:

$$\sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{p} c_{ijk} x_{ijk} = \text{minimum}$$

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Theodore Kallner of the Service Bureau Corp., 634 Madison Ave., New York City, provided extensive assistance in reviewing the linear programming models and suggesting the approach taken in the pulpwood procurement model.

Realistic Budget Control of Large Scale Contracts

J. G. NAGRO

While the use of budgets to control routine business operations has made great strides in recent years, the development of truly realistic systems to effect running budget control of nonroutine work such as large capital plant investment contracts has fallen behind this trend. The author contends that certain basic differences between capital plant work and that of the routine operations of a business have much to do with this development lag. The author cites as the principal difference between these two types of work, the non-repetitive nature of such jobs, which requires adherence to five fundamental concepts, different in nature or application from those required for successful control of routine operations. Among these concepts is the requirement that primary control of their cost-influencing activities be effected by those who are doing the work at the lowest operating levels. This is achieved through use of a complete set of job budget standards, combined with a system of job status and progress reporting which is based upon self-measurement and predictions of future cost. A future of this system is the requirement for high speed reporting of cost and progress, made necessary by the nonrepetitive nature of the work to be controlled. Traditional accounting data is not used in the system, except to verify, after the fact, the accuracy of the rapid-report data on which the system operates. Problems and objectives connected with the control of capital plant costs are basically the same for the owner who contracts for the work or the contractor who performs it. Costs of the system are kept well in line through savings achieved by use of operating data which is derived as a by-product of normal job supervision. The cost of operating the system is more than justified by the controlled atmosphere which it generates and the many additional benefits which it provides to the organization. In addition, the savings which its successful operation can make possible on the cost of a single job can far exceed the entire cost of the system for a long period of time.

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SINCE the end of World War II, corporate management has made important progress in learning how to use budgets and achieve realistic budget control over their day-to-day operations. Nevertheless, today many well-run organizations which exercise a high degree of cost control over their manufacturing operations, achieve little more than elementary cost control over their largest capital expenditure projects. In like manner, many engineering-contracting companies which handle large projects of a complex, long-term nature are today ill-equipped to achieve realistic control of their nob costs during the life of their most important projects.

Amazing though this statement may seem at first, a fair evaluation of the methods which are being used and the results which are being achieved during the life of many projects, bears out the substantial accuracy of this contention. In most cases, it is apparent upon careful investigation that all that is achieved in the guise of cost control is an after-the-fact record of how much money has been spent.

Naturally, our reaction to a statement such as this is largely conditioned by our understanding of what true budget control is and what it can achieve. Accordingly, I plan to go into some detail in my coverage of this point, since I feel that many organizations are today getting along with a relatively ineffective system because they have not carefully examined the overall problem and do not know what can be achieved in this field as a result of proper planning and hard work.

If you will concede for the moment that this presentation will develop the bssis for my opening statement, through a discussion of what realistic budget control is, let us now inquire: Why does this condition exist?

I believe that the major part of the answer will be found in the fact that:

1. For industrial organizations, large capital expenditure contracts are nonroutine matters which are intermittent in occurrence and usually quite different in nature, from job to job. Therefore, a complete set of cost experience factors and standards which are reliable for current use on such jobs

are usually hard to acquire. Also, the development of procedures, and the up-dating of current standards for following and controlling this out-of-the-ordinary type of transaction, often does not receive the same amount of attention that is accorded to the routine operations of the business.

2. For engineering-contracting organizations, each large, complex project is a one-of-a-kind operation, different in many details of design, location, economic climate, and duration from all other projects encountered in the past. Therefore, in essence the problems which the engineering-contractors face in setting up the means of exercising realistic control of their most complicated projects are about the same as those of their customers.

I am sure that most industrial organizations and engineering-contractors desire to achieve realistic control over this type of contract. I also believe that adequate control mechanisms could and would be developed if these organizations did not ignore or fail to properly evaluate the significance of the one fundamental difference between such projects and the ordinary, repetitive transactions of a business. This difference, which is so real and important that it requires the use of an entirely different type of record keeping and result-evaluation process, can be summed up in one descriptive word—nonrepetitive. To state the situation in terms of a simile, this type work is like a parade, which obviously you cannot guide or control by sitting in the normal reviewing stand. As each part of the parade is seen by you, it is past and gone and will never return again in exactly that same fashion. At this point, it is too late for you to try to get the boys into step. The section you have just reviewed will not be back to benefit by any improvements you may have thought of as it went by.

What would you do about such a situation? Simply locate yourself in a good vantage point, out in front of the parade as it comes along. Sight down along the guide lines and be sure that everything is in order and that everyone is prepared to march past the reviewing stand as you want him to. If anything seems to be headed out of line, this is the place to spot it and make corrections while there is still time to make this parade look the way you want it to. This is truly the place to exercise realistic control!

Translation of this concept into terms of a system which is realistic and also affordable is not simple. However, the key to understanding what must be done is found in understanding the basic concepts and requirements upon which such a system must be built. Since these are rather unique in a number of important respects, I plan to discuss them with you in terms of an actual system which has been in successful operation in our company for a number of years. Time has proved that this system is practical and successful, although I must admit that developing it and getting it into operation required a lot of faith in the fundamental concepts upon which it was founded.

In order to confine myself to those matters which are most likely to aid in conveying to you the broad picture of this system, I plan to discuss first a few brief definitions and the question of why we attempt to exercise budget control at all. After that, we will discuss the budget control pattern, the fundamental concepts upon which such a system must be based, and the setting of the necessary standards. I plan to wind up the presentation with a very brief look at the way the budget control system operates at Kellogg, as a result of our adherence to the pattern and concepts which we will discuss here.

DEFINITIONS

To insure that this presentation would be made on a practical level, my first step in planning it was to make a number of inquiries among people concerned with capital expenditure projects, and with project managers who operate in the engineering-construction field. These inquiries concerned two things:

1. What type of control systems are now used on large-scale contracts?

2. Is there a universal understanding of the terms which are used to describe such systems?

The answers I received indicate that there is a wide divergence of opinion—both as to the type and extent of the systems which are in use or considered practical, and as to the key words which are used to describe the details of such systems. Accordingly, it seems appropriate to spend a few minutes to define the terms and key words we will use. Those which I feel must be covered are found in the title of this talk—"Realistic Budget Control of Large Scale Contracts."

Let us start with the word "control," which is at the heart of our discussion. This seems to be a much misused word. Often it is used to describe systems which are simply devices established to achieve some hoped-for cost reductions through the use of after-the-fact reporting, even though these systems are without realistic means of pinpointing trouble spots promptly as they develop.

One dictionary tells us that "to control is to guide, swiftly and surely." I like that definition—it describes the action which *must* take place, if we are to properly discharge our broad and complete responsibility for the management and control of engineering-construction contracts, which of course includes their budget control. I propose that we use it from here on out.

The second key word for consideration is "budget," also a much-misused term. For the purpose of this discussion, I feel we should stay away from some of the definitions which popular usage has attached to this word, such as that in which "budget" is confused with "appropriation," and thought to mean an *upper limit* on planned expenditures; or where the word carries the implication of "low cost" or "inexpensive." I will agree that the proper *use* of budgets often results in a reduction of unnecessary or unwanted costs. However, such a definition does not apply in the case under discussion. Accordingly, for the time being let us stick to the simple dictionary definition of the term, which is: A budget is an estimate of the amount which can be spent.

Our last key word, "realistic," is one which often causes as much trouble as any. Everyone tends to define the term in light of the subject under consideration, and conditions his opinion as to what is "realistic" on the basis of his own knowledge and experience of that subject. For example, we are all familiar with the practice of setting goals which are unattainable, in order to induce maximum effort toward their attainment. A system which incorporates such practices *may* prove to be effective, but the goals themselves can hardly be described by the term "realistic," and will not be so considered by those who have to work with them.

Individual circumstances also bear heavily upon the correct use of this word. For example, in industries which enjoy reasonably constant product demand, the control which can be achieved by use of after-the-fact reporting can truly be considered "realistic," because of the constant nature of the sales trends. However, in industries where the product is of a one-shot, nonrepetitive nature, and the period-to-period demand fluctuates wildly, after-the-fact reporting would achieve no actual control—and therefore could not be considered "realistic."

Since the large-scale, one-of-a-kind contracts which are the topic of this discussion usually will involve many nonroutine characteristics, special care must be used in applying the word "realistic" to the control process we will discuss. With this in mind, let us leave the term, with the understanding that we are using it to imply full consideration of *all practical* aspects of the work to be done, and of the human nature of the people who will do it.

WHY CONTROL

Before launching into consideration of our realistic budget

control concept, one point which was raised several times during my preliminary investigation for this talk should be dealt with briefly. That point involves the fundamental question —"What is the real value of *any* type of control on large, one-of-a-kind projects?" Those who pose this question usually argue somewhat along these lines: "Since it can be assumed that as a result of the company's normal supervisory and managerial operations, everyone will do the best he can at all times to keep his costs in line, why spend the time and money to operate a control system which will not improve the end result materially?"

The question is legitimate and the point well taken—in a way. Naturally, if we find that a system will not materially improve the end result, it cannot be justified and *should* be abandoned. However, we believe that a system can be devised which will materially improve the end result, and that this argument is fallacious in its assumption of two points:

1. Employees will consistently operate at their maximum efficiency, even if they do not have practical standards to tell them where their efforts should have brought them at various points during the course of the job, and where they actually stand in relation to those standards." I believe that on large, long-term contracts, this is expecting too much of the people in your organization. To use another simile, I believe that this is a situation akin to expecting a person to drive a long distance across strange country, without a speedometer, roadmap, or milestones, while being held accountable for getting no traffic tickets for speeding and still arriving at his destination before a set date. Obviously, providing some realistic mileposts and rates of speed for each segment of the trip would improve the chances of a successful arrival.

2. "The only purpose of a control system is to keep the costs of the job in line." While cost control certainly is a vital purpose, it is by no means the only objective of the system we are discussing, which has integrated within it many other features of value to management and the line operation. A broad view of the operation of most companies indicates that among the other vital objectives of the budget control system which should be considered are:

Acceptance and by the operating people in the planning and executing of their regular operations, as well as the controlling of them.
Low cost operation, because its data are used for many operating purposes, as well as for control and reporting.
Data coordination which will insure that all parts of the organization know where they stand in relation to all others.
Period status reports:
  Supplying to management:
    The timing and amount of cash requirements.
    Capital expenditure progress reporting.
    Interim job profitability calculations (in the case of contractors).
  Supplying to the estimators:
    A quick updating of estimating factors and insurance that obsolete figures will be promptly replaced, as soon as experience and trend predictions so indicate. (This is a matter of vital concern to busy contractors.)
  Supplying to the operations staff:
    Unified job planning and operating control data, to insure that the job is proceeding on a coordinated basis, with no advantage to any segment of the organization (i.e., engineering, procurement, or construction) being gained at the expense of an excessive penalty to the other segments.
    Currently updated performance standard data for operations, and the investigation of off-standard performance, in time to permit corrective action.

From the above, it is apparent that there are a number of additional top management and operating management requirements which should be satisfied while carrying on the type of job control operation under consideration, at a cost consistent with the true value of the services rendered.

THE BUDGET CONTROL PATTERN

Now that we have discussed the definitions and reasons which form a background for our proposed system, and somewhat defined its type and level, we can pass on to consideration of the pattern to which such a system should adhere.

The Kellogg system adheres to the classic, four-step basic pattern which should govern all properly planned control operations of this nature. The steps are:

Planning—to set the goals established by management.
Measurement—to make periodic appraisals.
Decision—to evaluate and decide on the need for action.
Action—to regulate, supervise, and correct.

The first step in this system is twofold: to develop the opinions and requirements of management concerning each specific project; and to transmit these to the job organization through a formalized set of communications such as job plans, procedures, work standards, and the like. Effective communication of these opinions and requirements of management to the men who are handling the work is vital to the success of any budget-controlled operation. A system such as the one we are discussing provides an excellent means of conveying management's standards and know-how regarding individual jobs to those who are actually handling the jobs. It is also the best means of coordinating the activity on the jobs with the overall objectives of the business.

Because of this, the planning step is usually the most extensive and complicated one of the four, and the one through which management is able to inject the necessary degree of realism into the system.

The second step, measurement, which involves the quantity of work done, its cost, and the percentage of completion achieved, is also of great importance to your system, and must be performed with a good measure of common sense and realism. To be effective, responsibility for measurement and its resulting status reports must be assigned to a highly reliable area of your operating organization, with sufficient authority and good judgment to do a realistic job and not merely a series of clerical operations.

The final two steps, decision and action, are the pay-off steps of the plan. If the measurements disclose an unfavorable comparison with the plan, in time to permit an evaluation of the situation, the system can be considered to be properly set up if it permits time to make a decision on an appropriate remedy and to take effective action. This is the point at which the real skill of the control organization will be utilized, since they will not only be making straight comparisons of current status versus plan, but in many cases deciding where the current trends will lead the job by the time it is complete.

I am sure that by this time it is apparent that the development of an effective system of budget control requires a great deal of advance planning and careful attention during the progress of the job. While the information which will be acquired through analysis of traditional, after-the-fact job reports is valuable, it is of lesser importance to this type of a system, since by the time it is available it can only become a part of the planning and standard-setting data for subsequent jobs.

Now that we have reviewed the plan on which the system should be built, let us examine briefly the fundamental concepts to which it must adhere if it is to be realistic and effective.

FUNDAMENTAL CONCEPTS

The Kellogg cost control plan is based upon the following fundamental concepts:

1. The data used to report job progress and current status must be originated by the line-operation itself, wherever possible. In all cases it must be data which the line-operation groups readily understand and accept. There are three important reasons for this requirement:

First. Any data which the line organization produces for its own operating use, under proper procedural control, are likely to be current and factual. For example, the structural

superintendent must know every day how much steel he is putting up and what his rate of progress is, in order to set his own plans for the next day or the next week, and to have his men and material on hand when he needs them. If the procedures are properly planned, use of these data will be largely self-checking from one period to another, and the system will run little risk of receiving seriously incorrect data, after it has been in operation for a while.

Second. The operating people will soon acknowledge the accuracy of progress reports, performance measurements, and the like which are based upon their own data, thus making this basic part of the data both current and noncontroversial.

Third. By no means the least valuable advantage to this concept is the cost-saving derived through the use of such data. Since these are by-product operating data, which must be gathered anyway, this plan avoids duplicate gathering of parallel data for purposes of the system alone.

2. Basic control will be exercised best if it is exercised at the lowest possible working level. Those who do the work or directly manage the work from the position of first-level supervision, are the persons best situated to exercise the type of primary control which is required in order to guide and evaluate the work as it moves through the organization.

Here again, on a vital point, we find adherence to a classic rule of management, which says that the wider the gap between the worker level and that on which control is applied, the greater will be the lag and the slippage in the control process.

In order to exercise this primary control, the working organization must be provided with adequate control mechanisms, including a coordinated job plan and realistic budget figures stating what management expects of each group in terms of quantities, time, unit values, etc.

To be useful, these standards must be stated in terms which each level of the organization can readily interpret in relation to its own day-to-day work and the measurement thereof. It also must include a simple means of comparing actual performance to budget standards, often enough and simply enough to insure that the results can be used as guides to trends which may be developing, and to the taking of prompt remedial action.

3. The timeliness of the information used and the actions taken in connection with it must be current—beyond the ordinary record-keeping interpretations of that term. Unless you know in time, you cannot act in time to take corrective action.

In some cases, this requirement may involve even simple, day-to-day checks made by a few operating areas, of performance against standards. Later, when these data are recorded in tabular form for an entire period they will provide a usable achievement record for comparison against actual cost. It is obvious that if we expect to put our findings to use on the average engineering-construction job, we must have them while the particular area of work is still in progress, and the analysis of productivity trends, future performance predictions and the like can be fed back to aid in the guidance and planning of work which is still ahead of us.

4. Those who perform the work of the job must make periodic predictions of their future productivity and progress, which will be used as a reliable guide to assist themselves and management in determining where the job stands currently, and where it will wind up.

While there is great value in knowing what has been accomplished and what the cost of the job has been to date, reports of that type are of little value except for use by someone in making predictions of what future use performance will be. The information which management needs to know most is the expected cost of the completed job, since that is the final measure of the success achieved by the control operation, and the performance record which they must plan to live with in the future.

I have always felt that the average job-status repor stating where a job stands and what it has cost to dat places a somewhat unfair burden on the shoulders of those management who must read and use it. In effect, this r quires management to evaluate all the complex factors whic lie ahead, and to predict for them on the basis of the cos and progress which are reported as having been experience to date. While such a technique may work well in the r view of routine business operations which run along on a re atively consistent basis from period to period, it is not pra tical in the case of contracts such as we are considering her As a result, there is great danger that opinions formed on th basis by those who are not familiar with new conditons whic lie ahead will be incorrect and misleading.

On the other hand, it is entirely logical to place the respor sibility for making periodic predictions of future cost an progress on the shoulders of those who are doing the worl In the course of their regular operations, these men mus predict to themselves what they expect of the future, i order to schedule their next work assignments, material de liveries, man-power requisitions and the like. To requir that these predictions be recorded, and subsequently live with during following periods, is mighty good operatin experience. This experience improves as the job moves alon and the operating people are required to make later prediction which demonstrate that they did or did not make the earlie ones accurately. Accordingly, I am convinced that thos who handle the jobs on the basic operating levels are the onl ones who can make such predictions with any degree of ac curacy.

5. Accounting department data of a standard nature con cerning contract costs should be used as a check on the ac curacy of the estimates and performance forecasts, but not a a major part of the control function itself.

Because of the requirements of "good accounting practice and the delays which necessarily accompany the orderl booking of complete operating data, the use of the accountin records for anything but an after-the-fact check would in volve reporting delays which would negate the value of th entire system. I find that this is a trap into which man organizations fall. Since the accounting department is nor mally responsible for data gathering, and since it has a stand ard pattern for doing this work, there is a constant risk tha data of a timing and type not suited to the budget contro system will be used in place of the specialized data which ar required.

STANDARDS

I feel that with these five fundamental concepts in mind and a proper understanding of the objectives and defini tions which have already been covered here, there is only on more item of major significance to be discussed—the settin of standards which will convey management's hopes and re quirements to the operations people who must carry on th work of the jobs.

The word "standards," as we will use it here, should be con sidered to mean the entire range of performance criteria whic company management establishes for the job. This will in clude the job plan, the control procedure itself and most, im portantly, the material unit costs, the labor pay rates, the labor productivity level, the speed of engineering work the ability to keep the plant design within planned limits, and the like. Obviously, establishing a complete, coordinated set of standards, is a job of no mean proportions.

The setting of standards is by far the biggest job, in terms of sheer volume, which will be encountered in establishing a budget control system. The completeness and accuracy with which this is done will have a direct bearing on the suc cess of the system. In other words, in the standards area it can be truly said that benefit will be derived from the sys

tem only in proportion to the value of the standards which are put into it.

Standards usually have to be tailored to fit two factors which often are quite different—the estimating units and the operations units. Seldom is it possible to estimate a job on the basis of data which are detailed enough to be used without refinement for the later budget control of the operation. Nevertheless, if the system is going to be used to verify the accuracy of the estimating factors—which is a vital part of the system—a satisfactory reconciliation between these two factors must be achieved.

The obvious and most practical answer to the problem is to plan the standard divisions of total engineering, material, and construction effort, in such a way that a definite number of segments may be pulled together to match up exactly with the larger segments used for standard estimating. This is no small job, but its value will be obvious the first time that the total job cost and the total estimate price do not agree by an important amount and you find that the trouble cannot be localized for lack of estimate and cost figures which are comparable as to scope and content.

No single definition can be established to define the degree of detail which each organization should require in setting its standards, since each will have different methods of operating and supervising its jobs, and of keeping its cost records. Furthermore, the level and degree of control which management wishes to exercise will also condition the decisions on this point.

Accordingly, the best advice to those who wish to establish standards to be used for job budget purposes is to suggest that they study the control objectives which are to be achieved, the organization which will do the work, and the way in which the jobs will be built. With this information in mind, they will then break down the overall job into the smallest work segments for which estimates can be made and costs can be recorded without involving an impractical amount of paperwork detail. Do not lose sight of the fact that the basic thing which is to be controlled is the action of people. A system to achieve the maximum effectiveness should be built around the areas of responsibility of individuals, specific segments of the work force, materials which will be designed, brought, or handled by individuals or well-defined groups, etc. These will then become the segments of the budget breakdown, through which management will communicate to the specific parts of the organization, the specific performance levels which each is expected to achieve. Obviously, the more detailed the breakdown within the bounds of practicality, the easier it will be for the individual employee to use this as a day-to-day reference and guide, and the better will be the control he exercises at the primary level.

I feel that I cannot stress this point too strongly. As the work moves through the various phases of the job, the more check points which are available and equipped with realistic standards, the easier it will be for the organization to check its performance trends currently. In addition, corrective action can be taken on a time sequence which will be far ahead of the best schedules possible if the corrective action had to be ordered first only as a result of the disclosures made in a formal cost control report.

Another valuable aspect of the assignment of standards to small segments of the organization is found in the incentive value of telling employees how well they did in the achievement of the goals which were set for them by management. This point should not be ignored.

But what happens if an organization does not have historic cost information in the degree of detail necessary to set the type of standards we have been discussing? One solution is to set out at once to make numerous time studies, price trend analyses, labor cost and productivity inquiries, and the like. What of the cost? In this area the stakes are high, but the possible savings which can be achieved by forcing the organization to operate in a well-controlled atmosphere can far exceed the set-up cost over a relatively short period of time. Therefore, my advice is to go ahead and spend the money to develop an adequate system if you expect to handle any number of jobs of large size in the foreseeable future.

Obviously, there will be some among us who will not find it practical to plan to take on a commitment for a large cost outlay—either because their jobs are too infrequent, too varied in nature, or too small. Other reasons for such reluctance can be associated with management's unwillingness to take the necessary firm decisions, the impracticality of hiring temporary people to handle this type of work, the indefiniteness of future prospects, and the like.

However, in any event, if it is decided that the big job of setting standards in detail cannot be assumed, all is not lost. One solution would be to drop back to the next level, where standards would not be prepared in complete detail and the accountability areas of responsibility would include whole departments, sections, or the like. Often this is the way that an organization gets into a complete budget control operation—through the gradual development of more and more precise control as the value of such systems is demonstrated.

In the case of jobs on which no engineering has been done, or where it is of a developmental nature and little is known of the definite material and labor requirements, it is possible that you will have to ease into the establishment of budget control standards by means of setting tentative budgets for large segments and later replacing them with finalized budgets as the work is defined. In all cases where the engineering is not completely defined, some type of a tentative or preliminary budget should be set in order to provide the maximum control possible in light of what is known at the time. As the job becomes better defined, an orderly replacement of the tentative budgets should be provided for as rapidly as possible.

This same technique applies in any situation where complete budget standards are not available. The owner or the contractor certainly has some idea of the cost which will be satisfactory to him for each major segment of the job. Even this will furnish some basis upon which to exercise limited budget control, if he breaks down the segments and their expected cost into accountability units on an arbitrary but careful basis, and holds his organization responsible for meeting or exceeding these goals. You may be surprised at the ingenuity which your organization will display when they have specific goals to meet entirely within their own areas of responsibility.

USE OF CONTRACTORS' SYSTEMS

There is always another practical way for companies whose capital expenditures program does not appear to warrant the establishment of a full-fledged system such as we have been describing. This involves a suggestion which cannot be skipped in the interest of the completeness of this presentation, but which I hope will not be misunderstood and considered as improper commercialism on my part. The suggestion is to make use of a ready-made system by placing the contract for designing and building the new plant, with an engineering contractor who already has such a system in operation.

Several of the largest and most reputable engineering-contracting organizations which operate in the pulp and paper area have spent large sums in developing and refining high-powered systems to control and minimize their costs. The benefits of such systems can be derived by the customers of these organizations through arrangements made at the time the job contract is entered into, on either an open cost or a fixed price basis. In this way the customer will derive the benefits of a system which has been proved effective on a number of jobs and which the contractor uses as one of his more potent, competitive weapons. Some of these systems

will be far more complete and effective than anything which is otherwise available to the customer who does not have capital expenditure projects of the size and the quantity handled by the contractor. In addition, through such an arrangement, some very modern equipment, such as our new IBM 7070 computer, becomes available for budget setting and other control work, to customers who would otherwise have little opportunity to take advantage of such facilities.

In the case of open cost contracts, where all or a substantial part of the plant costs are chargeable directly to the customer as they are incurred, it is well to examine the contractor's budget control system which will be used to control and check on expenditures to be made for the customer's account. If no such system is available through your regular contractor, or if his system does not appear to be realistic and capable of achieving the degree of control you require, shop around among other contractors until you find one who can satisfy your needs. A reliable contractor with a good system should operate that system as conscientiously and efficiently for your benefit as he does for his own. To contract on an open cost basis without providing yourself with this up-to-date means of excess cost protection when you do not have your own system, appears to be incurring a needless risk which might prove very expensive if the job goes bad.

In the event that the contractor's system is available and appears adequate, by all means agree to any reasonable requirement he has for operating the system properly. Usually a few extra people must be added to the payroll which you are footing, in order to handle the necessary work. This cost can be only a trifle when compared with the cost of the materials and labor which it will control and the potential savings it can produce. It is good insurance, which should not be passed up.

Probably the simplest way to take advantage of a contractor's budget control system is to contract for the engineering and construction of your plant on a fixed price basis. Since a competitive bid will usually pass on to the customer the cost-saving effect of the contractor's budget control system, an owner will derive the benefits without incurring the costs and hazards which are inherent in developing and operating his own system for part-time use, or of having the contractor operate such a system for him on an open cost basis. Fixed price contracts which establish definite dates and amounts of payment by the owner, automatically shift the full budget control responsibility to the contractor, and the savings to the owner.

A SPECIFIC SYSTEM

Now that we have explored basic reasoning and concepts behind what we call a realistic budget control system, the construction of such a system is mainly a matter of applying common sense to the particular set of circumstances which hold in each individual case. As an illustration, I will briefly explain how the budget control system works at Kellogg.

As you might expect, our system is based upon a complete set of standards and performance norms, which have been gathered and interpreted over the past few years, and now are being programmed into the new IBM 7070 computer. As we have said earlier, proper standards are the key to a truly successful system, since these standards, norms, and trend statistics provide the budget factors for each job. These budget factors, in turn, provide those who are doing the individual work, with a usable statement of what is expected of them. With this, they exercise the primary control of the system, which is self-control. As mentioned earlier, all standards which are given to the primary level of the organization for use in controlling their activities are on the basis of units which will best facilitate the control operation of a group. In some cases these are dollars, in other cases they may be material quantity units, labor man-hours, productivity factors, or the like.

In some cases, our basic standards for productivity, labor costs, and the like are used "as is" for relatively long perio of time. In other cases, such as those involving the stan ards for material unit prices, the situation is always in t state of flux, and historic data may be used only in co junction with current trend statistics, forward prediction or the like. We operate on the theory that under no c cumstances is it safe, in these times, to carry forward e timating and budget-setting data from job to job blindl without subjecting it to test for current applicability.

In setting up our budget standards for individual job we do not wait until engineering is substantially comple before coming up with detailed material quantities, and t resultant material and construction cost factors. This wou practically eliminate the possibility of effectively contro ling the quantity planning and design work in engineerin and complicates the control of prices in purchasing.

Kellogg has solved this problem through the use of i computer. In this application the data on which each e timate was based are fed into the machine which already co tains our historic material relationship factors. As a resul in no time at all we are in possession of detailed materi quantity lists which can be used for preliminary purchasin activity, material cost estimating, construction labor e timating, and the like. These latter activities are also pe formed by the machine.

As quickly as each segment becomes ready, the budg control factors are fed out to the individual parts of the o ganization. Obviously, everything is not produced at onc nor can our people use all budget control standard data a one time. Therefore, a system of priorities and schedule dea lines is established to insure that those who need the da first receive them first, before their work is started.

As soon as all the budget control standards for any phas of the job are fed out to the organization, they are summarize on the basis of dollar value, and become the basis of sum mary reports which go to several levels of operating manag ment and corporate management. Whenever changes i job specifications or requirements are encountered, these a incorporated into the overall picture and the budget quantitie are changed to reflect the current job situation.

Except in unusual cases, all jobs are subject to a ful scale review at frequent intervals during their lives. Thes reviews are made on the basis of a logical breakdown of th overall activity. The overall engineering activity is usuall split into two or three segments, in order to insure that we ca evaluate the effectiveness of the work of the process grou the planning group, and the design group. As the work o each segment is completed, a prediction of the total cost o the segment at job completion is made and compared with th cost which was set forth by the total of the budget contro standards. This comparison provides an accurate appraisa of the effectiveness of the control effort which had been ex ercised up to then by the personnel at the working level. I this activity of comparison and analysis, the computer an tab equipment is used extensively in order to speed up th report findings, and sort out the insignificant aspects.

Let me inject one note of explanation at this point. The us of a computer is mighty handy in the operation of a large scal budget control system, but it is by no means a mandatory re quirement. The Kellogg system was originally develope and gradually enlarged to about its present proportions on th basis of a complete manual operation. Only during the las year or so has any appreciable amount of the work been han dled on our present computer. While the use of a compute or an extensive tab operation will permit you to achieve a degree of accuracy and timeliness which is impossible unde a manual system, many very valuable results can be achieve without any assistance of this type.

When the work of the total group is finished, a summariza tion of the individual pieces is provided to operating and top management, where it is compared with the summarized estimating data. The result is the first indication which man-

agement has of the effect of the primary budget control activities which have been carried on by the working levels of the organization.

It is true that when such information reaches management, it too may initiate certain control activities and the taking of corrective action, as well as ordering investigations to determine why parts of the primary control activity did not achieve better results. However, it is obvious that by the time the status data are combined, consolidated, and rendered in the form of a report, the work of the organization has moved on and is no longer susceptible, for this job, to many of the ordinary operating control techniques which are effective when applied on a very current basis.

After the checks which are made while the job is in engineering, additional checks are made in connection with the purchasing activity and the field construction force operation. All of these are carried on simultaneously during that part of the job when all of these activities are going on at the same time. Their timing depends entirely upon how the work progresses in each area. In all cases, the summary reports which are prepared for management are considered to reflect primarily the effectiveness of the control which the workers themselves have exercised at the operations level, and secondarily the effectiveness of the managerial control procedures and alertness which is exercised above the job operations level.

Periodically, a formal report of job status is made and supplied to top company management, forecasting how the job will look at completion on the basis of all facts and trends known to date. These reports are of great value to all levels of company and operations management, since they become the official record of company position on each job, whenever issued.

As each job progresses toward completion and reports are issued periodically to predict what the total final cost and profit position will be, a definite pattern of trends begins to unfold. The accuracy with which progress measurements and completion predictions have been made will become apparent quickly and the situations where costs or progress went off standard will be clearly decernible. In such cases it is a simple matter to review the running reports of trouble and corrective action, to determine if the employees at the working level did recognize the off-standard condition when it developed, and took prompt and appropriate action toward its correction. All matters not so covered can then become the subject of inquiry and analysis, in the interest of responsibility setting and the correction of faulty practices on future jobs.

As the data begin to come in from each job and establishes definite trend patterns, they should also be transmitted rapidly to the estimating department. Since this group is faced with the necessity of keeping their estimating factors on a completely current basis at all times, they should not be forced to wait any longer than is absolutely necessary for information which will verify or change the factors which are currently going into bids for future work.

Each time a progress and status report is issued, the various figures shown thereon for total job cost at job-end will contain a greater amount covering actual cost experience and a lesser amount covering future cost predictions. Eventually the last report will contain nothing but actual cost experience data. The accuracy of the future cost predictions which appeared in previous reports will be automatically checked out on a final basis through this process.

Under the Kellogg concept, the same degree of budget control is exercised and the same type of job status and result-analysis reports are issued to management for all jobs, whether they be open cost or fixed price. This philosophy is adhered to despite the fact that on some jobs (certain open cost contracts) we may be spending considerable sums to operate a system which saves money for the client but eats into the Kellogg fee. We do this since we wish to maintain at all times a "controlled atmosphere" within our working groups, which would not be possible to retain if we attempted to budget control only our fixed price jobs, while letting all open cost jobs go through without the benefit of this system. The philosophy behind this is that the contract terms of payment do not alter the basic need for control, of either Kellogg's own dollars or of our reputation for safeguarding and conserving the dollars which our clients must pay.

Obviously it is impossible in a presentation of this type to describe or even list in detail the procedures and reporting techniques which are required to operate this system. Over the past five years, Kellogg has built up two large procedure volumes, one for the home office and one for the construction sites, to govern the planning, control, report, and analysis work which must be done by each segment of the organization on each project. We believe that the existence of such procedures, in written form, is of as great importance to the success of the system as is the extensive set of control standards which we employ. Since we have many jobs in varying stages of completion which are going through the organization at the same time, it is imperative that our operations be subject to a well defined set of rules which are readily available to all properly concerned employees. To attempt to exercise budget control on behalf of individual jobs without this coordinating and unifying factor would certainly be folly.

CONCLUSION

In the foregoing we have reviewed the basic terms which are used to describe this system, the reasons why we believe a system of this nature is required, and the reasons why it must be constructed and operated in a manner which does not fit the pattern usually applied to budget control of routine operations. We then reviewed the basic pattern of planning, measurement, decision, and control upon which the system was to be constructed, and the five fundamental concepts upon which it is based. These concepts required that the data for the system must be line originated, that control must be exercised at the lowest possible level of the work force, that the data used must be of special timeliness, that the workforce must regularly predict its future performance out to the end of the job, and that accounting department data can only be used for verification purpose because of its lack of timeliness. We then reviewed in a general way, the basic requirements for setting up a standards system which will provide appropriate cost and performance standards to govern the budget control activities on each job. Some of the complications involved in setting up a realistic set of standards were reviewed and suggestions were offered concerning ways in which this requirement can be met on a common sense basis. The presentation was closed after a brief review of the way in which the budget control system works at Kellogg. Time availability did not permit the review of the specific forms or procedures which Kellogg uses, but a discussion of the system's objectives and method of operation was carried on.

I would like to conclude this presentation with the statement that the Kellogg system of budget control was not easy to establish, and will not now operate at peak efficiency unless it is continuously being improved and tailored to each individual job as that comes up. Nevertheless, I can say without hesitation that whatever we have invested in the system to date is considered by top management to be a worth-while investment.

The fact that the system exists and will probably bring to light all major evidence of careless or off-standard work, provides a mighty strong incentive to many employees who otherwise might not feel inclined to operate regularly at a work level approaching peak efficiency. In addition, the ability to spot out of line performance in design, purchasing, or construction in time to permit corrective action before the job moves on, has proved of great monetary value in many

cases. The many other benefits which are derived from the use of this system, on a by-product basis, are also of a most valuable nature and might alone justify the cost.

Accordingly, it is easy to say that Kellogg is happy with its present system and enthusiastically working upon its extension and computerization. We feel we have derived great value from its use, and plan to continue it in operation for all of the foreseeable future.

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Materials of Construction for a Bleached Sulfate Pulp Mill

J. M. JOPP

The scope of the paper basically covers the specifications of materials for buildings, major equipment, sewers, piping, electrical motors and cables, painting and roofing for a bleached kraft mill. It really summarizes the author's 34 years continuous experience in the pulp and paper industry, including newsprint, sulfite board, kraft and specialty papers where corrosion and service requirements always predominate. Unfortunately such a paper cannot give any indication of the constant changes over the years of most material specifications. A few of the basic items remain unchanged, but the almost universal use of the several austenitic stainless steels together with the more recent evolutions of plastics makes it imperative to constantly overhaul ones thinking to avoid the material losses that would result if the standards of yester-year were accepted.

Any attempt by an individual to write a materials specification for a modern pulp mill must contain many recommendations that will be controversial in nature. A survey of bleached kraft mills is certain to show a wide divergence in material selections for similar plant uses. It is not the author's intention to be dogmatic but rather to describe materials that have found wide acceptance for specified services and to be considered satisfactory from a corrosion viewpoint.

When I first gave thought to the composition of this paper it was my intention to establish a flow sheet and then follow it through in a normal sequence covering the individual items in each department. It soon became evident that such plans involved writing a fairly large book and so some means of condensing the subjects had to be found. By use of a tabular form of summary sheet it has been possible to cover the subject headings in a brief, but specific manner. The following order will be adhered to:

1. Buildings.
2. Piping.
3. Valves.
4. Digesters and brown stock system through screening, dirt separators and black liquor oxidation.
5. Bleach plant equipment including towers and screening and centrifugal dirt separators.
6. Pulp storage.
7. Drying machine—pulp finishing.
8. Agitators.
9. Pumps.
10. Ventilation systems.
11. Recausticizing—lime kiln, lime mud filter, etc.
12. Precipitator.
13. Evaporators.
14. Recovery unit.
15. Electrical.
16. Sewers.
17. Insulation and protective cover.
18. Painting.

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BUILDINGS

One accepted definition of the word corrosion is "Gradual Decay" and this aptly describes the effect of time and the elements on the exteriors of pulp mill buildings. The availability of local materials can influence the choice of exterior cladding for economic reasons. The following specifications are considered satisfactory and economical for a Pacific Coast bleached pulp mill. The use of fiberglass reinforced polyester translucent sheets in belts on transite cladded buildings is highly recommended. The advantages must be experienced to be fully realized.

Woodroom. Steel frame with concrete dado wall 4 to 6 ft. high, asbestos sheet cladding with one or more courses of translucent fiberglass sheets in place of windows, with wood roof deck and asphalt and gravel built up roof.

Pulping Group. (Including Digesters, Brown Stock Washing, Screening and Bleach Plant). 1. Reinforced concrete columns and masonry block walls. Precast or poured in place of concrete roof with asphalt and gravel built up roof.

2. Laminated wood roof beams and purlins made with waterproof glue, and cavity type asbestos roof deck as alternate to above.

Where earthquake design is necessary, this alternative specification can reduce total roof and beam weight by approximately 65 lb. per sq. ft. of roof area for a 500-ton mill. Material and erection costs are reduced and erection speeded up to 25% using alternative 2.

Recausticizing. Steel frame, transite cladding, green belt fiberglass translucent sheets, asphalt and gravel roof.

Steam & Power Group. Steel frame, concrete or block dado wall, asbestos cladding with necessary courses of green translucent sheets for light. Precast or cavity-type roof deck with asphalt and gravel built-up roof.

Machine Room. Concrete frame, masonry block walls, precast long span roof deck, asphalt and gravel built-up roof or laminated roof beams and purlins with cavity-type deck—asphalt and gravel roof. Total roof load can be halved by use of second alternative.

Pulp Storage. Steel frame, asbestos siding with one or two courses of light green translucent sheets for light. Glue laminated long span roof beams with wooden purlins and cedar deck with asphalt and gravel built-up roof.

PIPING

Table I lists the materials of construction for the major piping requirements. The numbers in the columns indicate the first, second, third choices, etc., for the service specified.

Since corrosion residue is a major source of dirt in pulp, the emphasis in this list is directed toward cleanliness. In a competitive industry, cost must also be a governing factor, therefore the choices have been guided by such factors as maintenance costs, expected length of service and installed costs as well as corrosion resistance. The choice of materials for piping is almost unlimited and requires careful study by the design engineer to have a satisfactory material for the various services in a sulfate pulp mill. The rapid development of plastics for piping materials makes it possible for the engineer to meet almost any corrosion problem encountered. I am listing some of the materials now available and the services for which they should prove adequate. Elevated temperatures are generally the controlling factor.

Polyethylene. Chemical resistance fairly good; deteriorates in sunlight unless compounded with carbon black or other ultraviolet light protector; service for fresh water where weight is a major factor such as hoses, temporary water lines, etc.

A.B.S. Polymers. Acrylonitrile, butadiene-styrene; chemical resistance good, can be obtained in several grades for specific uses; Kralastic is one trade name of pipe that can use threaded couplings in rigid form.

Table I. Piping

Service	Cast iron	Carbon steel	Polyester resin fiberglass reinforced	Extruded fabricated aluminum	Copper saran lined	Lithcote or similar linings	Transite	304 SS	316 SS	317 SS	Glass	Wood-stave pressure creosoted	Steel coal tar enamel coated inside and outside
Process fresh water	..	..	..	1	..	2	3	..	..	..	..	..	..
Underground fresh water	2	..	..	..	..	..	3	..	..	..	..	..	1
Drinking water	..	..	..	..	1	..	..	..	..	..	..	1	..
Long viaduct	..	..	2	..	..	..	..	..	..	..	..	..	..
Whitewater and stock	..	..	..	..	..	..	..	1	1	..	..	..	..
Condensate	..	1	..	..	..	..	..	..	..	..	..	..	..
Oil-hydraulic system 0–2000 lb.	..	1	..	..	..	..	..	..	..	..	..	..	..
Steam	..	1	..	..	..	..	..	..	..	..	..	..	..
Blow piping	..	..	..	..	..	..	..	..	..	..	..	..	..
Air lines	..	2	..	1	..	..	..	1	..	..	..	..	..
Black liquor weak	..	1	..	..	..	..	..	..	..	..	..	..	..
Green liquor	..	2	..	..	..	..	..	..	..	..	..	..	..
White liquor	..	..	..	..	..	..	..	1	..	..	..	..	..
Causticized liquor	..	..	..	..	..	..	..	..	1	..	..	..	..
Drain pipes	1	..	..	..	..	..	..	2	1	..	..	..	..
Natural gas undergound, 60 p.s.i.	..	1	..	..	..	..	..	2	1	..	..	..	..
Chlorine gas	..	1	..	..	..	..	..	..	..	..	..	..	..
Dry	..	..	..	..	1	..	..	..	..	..	..	..	..
Wet	..	..	..	..	..	..	..	..	..	..	..	..	..
Chlorine dioxide liquid	..	..	..	..	1	..	..	..	..	..	2	..	..
Chlorine dioxide gas	..	..	..	..	..	..	..	..	..	..	1	..	..
ClO_2 treated stock	..	..	1	..	..	..	..	..	..	2	..	..	..
ClO_2 white water	..	..	1	..	..	..	..	..	..	2	..	..	..
Evaporators:													
Vapor	..	1	..	..	..	..	..	..	..	..	..	..	..
Nos. 1 and 2 effects recirculation	..	..	..	..	..	..	..	1	..	..	..	..	..
Other effects	..	1	..	..	..	..	..	..	..	..	..	..	..
Nos. 1 and 2 liquor strong	..	..	..	..	..	..	..	..	..	..	..	..	..
Other effects	..	1	..	..	..	..	..	..	..	..	..	..	..
Condensate	..	1	..	..	..	..	..	..	..	..	..	..	..

Saran or Vinylidene Chloride. Excellent corrosion resistance; brittle, relatively heavy. Finds many uses as internal lining for steel pipe and fittings.

Fluorocarbons—Teflon—Kel-F. Exceptional chemical corrosion resistance; stable over a wide temperature range, −200 +500°F.; structurally weak but excellent for pipe linings, etc. Laminated pressure pipe is available.

Acrylic Resins. Lucite and Plexiglas are mainly used for tubing where visual observation is essential.

Rigid Polyvinyl Chloride (P.V.C.). The rigid or unplasticized P.V.C. has high strength, excellent corrosion resistance, and will not support combustion. It can be molded into flexible pressure tubing when plasticizer is used; frequently used for lining steel pipe.

Butyrate. Cellulose acetate butyrate (tenite) has found many uses from gun stocks to piping liners and inserts; corrosion resistance to chemicals is not high; deteriorates when not protected from the elements; brittle at low temperatures and will support combustion.

Polypropylene. New in the plastics field; stronger than polyethylene and capable of withstanding higher temperatures; good chemical resistance.

Chlorinated Polyether. Trade name Penton; highly heat resistant and chemical resistance approaching the fluorocarbons (Teflon).

Aromatic Polycarbonate Resins. (Lexon) Strong, chemically resistant and withstands oil. (Polyacetal Resin—Delrin) Excellent chemical resistance; excellent stability under stress; should find many piping uses.

Glass-Fiber Reinforced Epoxy and Polyester Resin Pipe. High temperature resistance; high impact strength; excellent chemical resistance for low pH.

This list is used to emphasize the wide range of plastic materials now available to meet the many requirements in pulp mills. A large percentage of these products finds economic usage for process piping in modern pulp mills. The rapid development of this class of material is one of the major advances in recent years and provides a tremendous tool for the process design engineer.

VALVES

Table IV covers the various services and the valve materials considered adequate. Space does not permit discussing the functional aspects of the several classes of valves but simply designates materials to resist the chemicals present. A gate valve used for throttling service might be completely inadequate from a service viewpoint yet the material specifications could be satisfactory. I have not included the squeeze-type rubber valve which has found favor with some operators. I have no opposition to it for specified services but the applications are rather limited for such valves.

DIGESTERS AND BROWN STOCK SYSTEM THROUGH SCREENING, DIRT SEPARATORS, AND BLACK LIQUOR OXIDATION

Batch Type Vessels. The older kraft mills used carbon steel digester shells exclusively. With the advent of the modern types of recovery boilers, the corrosiveness of the liquor increased and digester shells corroded out faster. The experience of a mill that I was associated with, and at which I had access to the digester records, was roughly as follows:

This mill started bleaching with chlorine, caustic, and hypochlorite about 1921. The first digesters were under 10 ft. diam. and 1.125-in. thick plate. Twenty-six years was the maximum life but several lasted around 22 years. With the installation in 1942 of a modern-type recovery boiler for part of the liquor reduction, an increase in digester corrosion was evident and it appeared as if 17 years would be an average digester life. Stepped up production during the war years appeared to accelerate corrosion and replacement digesters had a useful life of eleven years. In 1951 the second modern recovery boiler was installed and all the older horizontal boilers were taken from service. Again there was evidence of

a decrease in digester life. At this time all replacement digesters were 10 ft. 6 in. diam. by 44 ft. and made from $1^3/_4$-in. type A 212 steel. These vessels were being replaced in approximately 7 years. With costs related to the early 1950's, digester replacements were approximately $0.50 per ton of pulp produced.

Experience indicates that the corrosion of mild steel "batch" digesters is most severe in areas subjected to spattering of liquor during the filling operation while the temperature of the shell walls is high enough to cause rapid evaporation.

Several means of combating kraft digester corrosion have been tried. One eastern Canadian mill tried, with some

Table II. Agitators

Service	*Rubber covered*	*Steel*	*304 SS*	*316 SS*	*317 SS*	*Phenolic coated*	*Cast meehanite*	*Titanium*	*Hasteloy "C" lined*	*Remarks*
Blow tank	..	1	1	..	..	..	..	..	..	Steel if slow moving arm, type 304 if impeller type
Brown stock washer repulper	..	1	..	..	..	..	..	..	..	...
Bleach washers	..	..	..	..	1	..	..	..	..	...
Brown stock storage	..	..	..	1	..	..	..	..	..	...
Bleach stock storage	..	..	..	1	..	1	..	..	..	...
Blending tanks (stock)	..	..	1	..	..	1	..	..	..	Wall insert, 316 SS
Lime mud filter	..	..	..	..	..	..	1	..	..	...
Causticizers	..	..	1	..	..	..	..	..	..	...
Lime mud storage	..	1	..	..	..	..	..	..	..	...
Smelt tank	..	..	1	..	..	..	..	..	..	...
Salt cake mixing tank	..	1	..	..	..	..	..	..	..	...
Chemical ash tank	..	1	..	..	..	..	..	..	..	...
Chlorine mixer	1	..	..	..	..	..	..	..	2	...
Chlorine dioxide mixer	..	..	..	..	..	..	..	1	..	...
Mixer—steam and pulp	..	..	..	1	..	..	..	..	..	....
Chemical ash	..	1	..	..	..	..	..	..	..	...
Knot tank	..	..	1	..	..	..	..	..	..	304 SS shaft
Unbleached screen chest	..	..	1	..	..	..	..	..	..	Ryertex bearing wall insert 316 SS, wall ring 316 SS
Tailing chest	..	..	1	..	..	..	..	..	..	...
Caustic bleach tower circulator	..	..	1	..	..	..	..	..	..	...
Steam and chemical mixer (NaOH)	..	..	1	..	..	..	..	..	..	...
High density pump (NaOH)	..	..	..	1	..	..	..	..	..	...
Chlorine dioxide tower	..	..	1	..	1	..	..	..	..	...
Hypo tower	..	..	..	1	..	..	..	..	..	...
Chlorination tower	1	..	..	..	..	..	..	..	..	Over 316 SS
Tower scraper (Cl 2)	1	..	..	..	..	..	..	..	..	...
Dilution nozzles	..	..	1	..	..	..	..	..	..	...
Shredder and conveyer NaOH	..	..	..	2	1	..	..	..	..	...
Hypochlorite stage										
Steam and chemical mixer	..	..	..	1	..	..	..	..	..	...
High density pump	..	..	..	1	..	..	..	..	..	...
Tower circulators	1	..	..	..	..	..	..	..	..	Over 316 SS
Dilution nozzles	..	..	..	1	..	..	..	..	..	...
Shredder and conveyer	..	..	..	..	1	..	..	..	..	If ClO_2 used, 316 if no ClO_2 is involved
Chlorine dioxide stage										
Steam and chemical mixer	..	..	..	1	..	..	..	..	..	...
High density pump	..	..	..	1	..	..	..	..	..	...
Chlorine dioxide mixer	..	..	..	..	..	..	..	1	..	Casing lined, all other parts solid titanium
Tower circulators	..	..	..	..	1	..	..	..	..	...
Dilution nozzles	..	..	..	..	1	..	..	..	..	...

Table III. Pumps

Service	*Casing*	*Impeller*	*Shaft*	*Shaft sleeve*	*Wear casing*	*Rings impeller*	
Stock							
Unbleached kraft	CI	304	316	17–4 PH	29% Cr	29% Cr	Note: 17–4 PH-precipitation hardening—SS casting
Bleached kraft	11–13 Cr	11–13 Cr	410	17–4 PH	11–13 Cr	11–13 Cr	.....
White water	CI	304	316	17–4 PH	29% Cr	304	.....
Black liquor	CI	304	316	17–4 PH	29% Cr	304	Except at evaporators
Chlorine treated stock	317 ELC	317 ELC	316	317 ELC	317 ELC	317 ELC	.....
Caustic treated stock	316	316	316	17–4 PH	29% Cr	29% Cr	.....
Hypochlorite treated pulp	316	316	316	17–4 PH	29% Cr	29% Cr	.....
Chlorine dioxide treated pulp	317 ELC	317 ELC	316	317 ELC	317 ELC	317 ELC	Note: 316 shaft because it is protected by a sleeve
Fresh water	CI	11–13 Cr	410	11–13 Cr	11–13 Cr	11–13 Cr	.....
Hot water	CI	11–13 Cr	410	17–4 PH	11–13 Cr	11–13 Cr	.....
Recausticizing	CN-7M	CN-7M	Shaw. 20	CN-7M	CN-7M	CN-7M	Note: 21–31 Ni, 18–22 Cr, 1.5 Mo, 0.07 max. C, CN-7M
Black liquor evaporator service	Worthite or equal	Worthite	...	...	...	...	Worthite Anal. Cr 20%, Ni 24, Mo 3, Si, 3.25, Cu 1.75, Mn 0.6, C 0.07
Thick stock pumps, high density	...	...	1	...	...	...	.....

Table IV. Valves

Service	Al	304 SS	316 SS	317 SS	All iron stainless trim	All iron	Steel rubber lined	Steel Saran lined	Glass	Phenolic resin coated	Fiber glass reinforced polyester resin	Ni resistant	Shaw & Carpenter 2
Blow valves	..	..	1	..	..	..	..	.	..	..	..	..	
Evaporator:													
Liquor	..	..	..	..	1	.	..	..	..	..	..	..	
Condensate	..	..	..	..	1	..	..	..	.	..	..	..	.
Brown stock	..	..	..	..	..	1	..	..	..	.	..	..	.
Bleached stock	..	..	..	..	1	..	..	..	..	.	..	..	.
Green liquor	..	..	..	..	..	..	..	..	..	.	.	..	.
White liquor	..	..	1	..	..	..	..	..	..	.	.	1	.
Black liquor	..	..	..	..	..	..	..	..	..	..	..	..	.
Evaporator service	..	1	..	..	..	1	..	..	..	..	..	..	..
Chlorine solution	..	..	..	..	..	..	..	..	..	..	..	..	..
Chlorine gas	..	..	..	..	..	..	..	1	..	..	..	..	.
Chlorine dioxide solution	..	..	..	..	..	1	..	..	..	..	..	..	..
Hypochlorite solution	..	..	..	..	..	..	..	1	..	..	..	..	..
Caustic solution	..	..	..	..	..	..	1	..	..	..	..	..	..
Liquid SO_2	..	1	1	..	..	1	..	..	..	..	..	..	..
H.C.L.	..	..	..	..	..	..	..	..	..	..	..	..	..
H_2SO_4	..	..	..	..	..	..	..	..	..	..	..	..	..
Fresh water	1	2	..	..	..	..	..	..	..	..	..	..	1
White water	..	1	..	..	..	..	..	..	..	..	..	..	..
Methyl alcohol	..	..	..	..	..	..	..	..	..	..	..	..	..
Turpentine	..	1	..	..	..	1	..	..	..	..	..	..	..
Condensate	..	1	..	..	..	..	..	..	..	..	..	..	..

measure of success, suspending lightweight mild plates inside the standard carbon steel digester. Experience proved that corrosion was greatly reduced in the digester shell. In fact, in the loosely hung plates, corrosion was not serious.

This type of lining has the disadvantage of reducing the capacity of the vessels in which they are installed and it is probable that this loose type of lining will tend to increase maintenance costs.

The practice of using a stainless steel overlay in carbon steel vessels where the corrosion allowance has been lost is being tried in some mills. I am very skeptical of this method of repair. These feelings are based on actual experience with small badly corroded areas where the method was tried. In my opinion, dilution of the stainless rod is so great that the effectiveness of the alloy is lost.

Where cleanliness is a predominate factor the use of Inconel-clad sulfate digesters must be considered. It is probable that over a period of 20 years' continuous operation for a bleached kraft mill, this type of digester will be superior and produce pulp of a superior quality at a lower price per ton. We used Inconel liners in the lower blow nozzle and in the circulating nozzles for several years with complete satisfaction. These vessels were $1^3/_4$-in. thick and normal life of shell was under 2 years. There are a number of Inconel-lined kraft digesters in service for periods approaching 10 years and the records of these vessels indicate a probable service life expectancy of 30 years.

Carbon brick-lined mild steel vessels have been tried. In American the experience does not appear to be too favorable and the use of such vessels has been very limited.

Continuous Types. Operating experience with continuous digesters has shown that corrosion of the vessel plate is not generally serious. This fact lends credence to the generally accepted hot plate theory as a major cause of batch digester corrosion. In the continuous process the vessel remains at a relatively uniform temperature, hot liquor is fed in continuously and the erosive action of free falling chips is absent. The absence of these factors appears to mitigate corrosion in these vessels and permits the general use of mild carbon steel.

SPECIFICATIONS
Batch: Shell—ASTM Spec. A—285 grade "B" firebox quality. Corrosion allowance 0.75 in.
Continuous: Shell—ASTM Spec. A—285 grade "C."
Strainer plates—type 304 SS.
Dilution nozzles—type 304 SS.
Internal pipe—type 304 SS.
Bottom head lining $^1/_4$ in.—type 304 SS plate.
Corrosion allowance $^3/_8$.
Top head lining 316.

Blow Tanks. Generally, only the target area requires special material and this is largely an erosion problem. Various types of stainless steel have been used with little if any advantage over mild steel. ASTM grade 5130 has been used in this service with excellent results. Again those mills whose wood supply is floated down streams with sandy bottoms have the most severe erosion in the blow tank target area.

SPECIFICATIONS
Shell—ASTM—A 283 grade "C" plate.
Corrosion allowance $^1/_8$ in.
Target—ASTM 5130.

Brown Stock Washers.

Vats: Mild steel.
Mold:

Head and shell	Steel
Ribs	304 SS
Winding wire no. 9 gage	304 SS
Face wire—40 mesh	316 SS
Front trunnion	Cast steel
Shaft	Forged steel
Inlet box	Steel
Valve	Cast iron
Bearing	Bronze
Take-off rolls	Steel
Doctor	304 SS
Repulper & shredder	Steel
Press rolls	Cast iron
Splash shields	304 SS

Seal Tanks. Steel or tile. If steel is used allow $^1/_8$-in. corrosion.

Black Liquor Oxidation Tower. Steel—$^1/_8$-in. corrosion allowance.

Brown Stock Storage. Steel—$^1/_8$-in. corrosion allowance.

Brown Stock Screens. All parts in contact with the stock type 316 SS.

Centrifugal Dirt Separators. Type 316 SS.

BLEACH PLANT EQUIPMENT

Washer Vats. As for the brownstock washers there is a wide range of specifications possible.

Table V. Conveyors

Service	Hardened carbon steel	Cast malleable iron	Alloy steel	Rubber belt on idler	Air float	Malleable iron and carbon steel	Cast steel	Fluid	Air	Bucket elevator	Mass flow cast steel	Fiberglass reinforced polyester trough and rubber belt
Log haul	..	..	1	..	..	..	..	..	..	..	..	..
Wood yard	..	2	1	..	..	..	..	..	..	..	..	..
Wood transfer service	..	..	1	..	..	..	..	..	..	..	..	..
Refuse—Hog fuel	..	..	..	..	..	2	1	..	..	..	..	..
Hot clinkers and ashes	..	..	..	..	..	..	1	..	..	..	..	..
Sawdust	..	..	..	..	..	1	..	..	..	..	..	..
Knots	..	..	..	2	..	..	..	1	..	..	..	..
Hot lime	..	..	..	..	..	..	..	..	2	1	1	..
Salt cake	..	1	..	..	..	..	..	..	..	..	..	..
Lime	..	..	..	1	..	..	..	..	2	1	..	..
Coal	..	..	..	1	..	..	..	..	..	..	..	..
High consistency pulp, no plows	..	..	..	1	..	..	..	..	..	..	..	..
High consistency pulp, plow transfers	..	..	..	..	..	..	..	..	..	..	..	1

Hollow tile; concrete, tile lined; steel, tile lined and stainless steel. Where pointing is necessary, polyester resins should be used for all stages except the caustic. Portland cement and sand is adequate for this stage.

Many mills have experienced cracking and high maintenance costs with concrete tile lined vats. Generally this is caused by the variable cross-section area of the vats experiencing different shrinkages and consequent cracking.

Steel saddles between the floor structural members was completely feasible for washers up to 8 ft. diam. but steel becomes massive for the larger diameter units.

The advent of one or more stages of chlorine dioxide bleaching and economy from maximum water reuse can sometimes justify type 317 stainless steel for all vats. I believe though that hollow tile vats pointed as mentioned above will generally prove most economical and should receive careful consideration for any new installation.

Chlorine Stage.

Mold type—317 SS E.L.C.
Inlet box type—317 SS E.L.C.
Seal tank—steel with single course of tile with polyester resin pointing.

Caustic Stage. Washer where counter current flows is used and maximum reuse of wash water is accomplished.

Mold type—317 SS E.L.C. Second choice 316 E.L.C. If no ClO_2 in system, C.I. or steel will be satisfactory.
Inlet box type—317 SS E.L.C.
Seal tank—steel shell, single course tile with polyester resin pointing.

Hypochlorite Washer. Washer where countercurrent flows is used and maximum reuse of wash water is accomplished.

Mold type—317 SS E.L.C.
Inlet box type—317 SS E.L.C.
Seal tank—steel shell, single course tile with polyester resin pointing.

Chlorine Dioxide Stage. All type 317 SS E.L.C. as foregoing. The use of one or two stages of ClO_2 with countercurrent flows makes the use of type 317 SS E.L.C. desirable and economical as compared with less costly materials that could be used as a compromise.

Towers.

CHLORINATION STAGE:
Shell-top, bottom and launder—steel—corrosion allowance nil.
Tile lining: Salt glazed, vitrified semistone ware. Single course $^3/_4$ in. thick.
Grout & pointing: Polyester resin acidproof.
Alternative: Welded steel shell, rubber lined. If properly installed this type of lining gives exceptional service, though some unexplained failures are recorded.
CAUSTIC STAGE:
Shell, top and bottom—mild steel.
Tile lining: Salt glazed, vitrified, semistone ware. Single course $^3/_4$ in. thick.
Grout & pointing: Portland cement—sand.
HYPOCHLORITE STAGE:
Shell top and bottom—carbon steel.
Tile lining: Salt glazed, vitrified semistone ware. Single course $^3/_4$ in. thick.
Grout & pointing: Polyester resin acidproof.
CHLORINE DIOXIDE STAGE:
Shell, top and bottom—carbon steel—corrosion allowance, nil.
Tile lining: Salt glazed, vitrified, semistone ware, single course, membrane-rubberized plastic troweled on the steel shell.
Grouting & pointing: Polyester resin cement.

PULP STORAGE

Raw Stock Storage. Mild steel, $^1/_8$-in. corrosion allowance. My recommendation for tanks used for pulp and water mix-

Table VI. Gasket Material

Service	Rubber	White asbestos	Blue asbestos	Teflon or Kel-F	Plasticized P.V.C.	S.S and asbestos
Water	1	..	..	..	..	..
Steam l.p.	1	1	..	..	..	..
Steam h.p	..	..	..	..	..	1
Caustic	..	1	..	..	..	..
Acid	..	..	1	..	..	..
Chlorine	..	..	2	..	..	..
Chlorine dioxide	..	..	2	1	2	..
CO_2	..	..	1	..	..	..
H_2SO_4	..	..	1	2	..	..
H.C.L.	..	..	1	2	..	..
Methanol	..	1	..	..	..	..
NaOH	..	1	..	..	..	..
Green liquor	..	1	..	..	..	..
White liquor	..	1	..	..	..	..
Black liquor	..	1	..	..	..	..
Recausticized liquor	..	1	..	..	..	..
Hypochlorite	..	..	1	..	..	..

tures is to use a steel tank with 18,000 p.s.i. tensile strength neglecting corrosion allowance material. For vertical-type tanks the stresses in the material where the bottom plates join the vertical side is difficult to analyze and it is good practice to avoid installing openings in this section unless they are adequately reinforced. Radiused corners, while expensive, effectively eliminate the high stress areas and avoid failure due to cracks at this junction.

Bleached Stock Storage. Many materials are adequate for this service. Concrete shell, tile lined, ceramic tile with polyester resin mortar joints, steel with phenolic coating and woodstave. With due consideration to utility and cost, I must recommend woodstave construction using preferably the more resistant woods such as cypress or yellow cedar.

DRYING MACHINE—PULP FINISHING

Wet End: Fourdrinier.

Headbox	Type 304 SS
Breast roll	Bronze
Table rolls	Carbon steel rubber covered
Couch roll	Bronze—specifications alter with PH
Dandy roll	Bronze
Draw roll	Aluminum
Wire rolls	Steel rubber covered
Presser roll	Steel rubber covered—200–225 P&J
Suction boxes	Type 304 SS
Suction box covers	End grain maple wax impregnated
Slice	All parts in contact with stock, type 316 SS
Distributor roll	Type 316 SS
Shower pipes	Brass equipped with piston-type cleaners
Breast roll doctor	Composition blade, steel back incased 304 SS
Saveall	Pan of type 304 SS supported on SS angles

Cylinder Mold:

Headbox	316 SS clad
Shell	316 SS
Ribs	316 SS
Wire	316 SS
Vat	316 solid or clad
Valve	316 SS
Extractor roll	316 SS
Shower pipes	304 SS or bronze
Takeoff roll	Rubber covered
Press rolls	Rubber covered

First and Second Bottom Press Suction Rolls.

Type 410 SS with 1-in. rubber cover, 25–35 P&J

First and Second Top Press Rolls.

Steel bronze covered

Third Press.

Bottom roll steel rubber covered 3/4 in.—10–15 P&J rubber cover

Top press roll—steel with 3/4 bronze cover

Wet Felt Rolls.

Steel 1/4 in., 0–10 P&J rubber cover

Pre-driers.

Shell	Cast iron
Heads	Cast iron
Drainer	Double rotary type
Steam joint	Carbon disk type
Condensate piping	Steel

Driers.

Cylinder Type:	
Shell	Cast iron
Heads	Cast iron
Felt rolls	Steel
Drainer	Rotary type
Vacuum Type:	
Cylinders:	
Shell	Cast iron
Heads	Cast iron
Sea rolls	Bronze with 0.008 chromium plating
Drainers	Double rotary type
Steam joint	Rotary, carbon disk type
Condensate piping	Steel
Conveyor Type:	
Casing	Steel frame, aluminum sheeting
Conveyor chain	Alloy steel
Tubes	Alloy steel
Heat recovery	Aluminum sheeting or 304 SS channel type
Water heaters	All type 304 SS
Condensate piping	Steel
Airborn Type:	
Casing	Steel frame aluminum sheeting
Transfer rolls	Steel
Water heaters	All type 304 SS
Heat recovery	Aluminum or type 304
Condensate piping	Steel
Decks	Steel
Fan cones	Steel

Sheet Cooler.

Steel frame, aluminum casing

Baling Press.

Platens	Open-hearth annealed cast steel
Main ram	Close-grained hard iron
Piston rods	Forged steel
Columns	SAE 4140 forged steel

AGITATORS

Table II lists the material specifications for agitator services generally found in a kraft mill. The list primarily indicates materials that have proved adequate in actual service. The fact that material is not listed does not detract nor condemn it but rather that the author has not had experience with it for the service indicated.

PUMPS

Table III lists materials of construction for all pump services in a bleached kraft mill. Again the list indicates materials proved adequate in actual service. Undoubtedly many readers will take exception to the choices shown as their individual experiences will lead the mto other conclusions. Again I must state that no materials are being recommended except as proved by actual experience to be satisfactory, but they may not always be the ideal. The addition of proved superior materials to the specifications will be appreciated.

VENTILATION

For a bleached kraft mill, ventilation is extremely important for several reasons. Personnel comfort and elimination of respiratory aggravations are of first consideration. Scavenging of corrosive vapor is essential to avoid high maintenance costs to equipment, particularly the electrical apparatus and, thirdly, the removal in the air stream of dust particles that would otherwise settle out as dirt in the pulp sheet.

A modern type of bleached pulp mill will require from 600 to 850 c.f.m. of intake air per ton of finished pulp. This figure will vary widely from mill to mill but the average will likely fall within these limits for satisfactory ventilation. The type of washer hoods is the largest control factor. The writer observed one 600-tone bleach plant with 112,000-c.f.m. fan capacity that was inadequate because of the type of hoods employed, while a similar washer installation with close fitting hoods required only about 16,000 c.f.m. to achieve better room conditions.

Fiberglass reinforced polyester resin is a satisfactory material for washer hoods and ductwork in the pulping group. Aluminum is a satisfactory material for ventilating requirements in the wood room and machine room. Experience in the power group and recausticizing buildings shows that aluminum serves satisfactorily in areas where some caustic

Table VII. Ventilation

Service	Fiberglass reinforced polyester resin	Fiberglass reinforced resin epoxy coated	Aluminum	Aluminum rubber covered	Aluminum epoxy coated	Steel	Steel rubber covered	Type 304 SS
Pulping Group								
Intake	..	..	1	..	..	..	..	..
Fan wheel	..	..	1	..	..	..	..	..
Duct	1	..	..	..	..	..	..	..
Brown Stock Washing								
Hood	1	..	..	..	..	..	..	..
Duct	1	..	..	..	..	..	..	..
Fan runner and shaft	..	..	..	..	..	..	..	1
Caustic Washers								
Hood	..	1	..	..	..	..	..	..
Ducts	..	1	..	..	..	..	..	..
Hypochlorite Washer								
Hood	1	..	..	..	..	..	..	..
Duct	1	..	..	..	..	..	..	..
Chlorine Washer								
Hood	1	..	..	..	..	..	..	..
Duct	1	..	..	..	..	..	..	..
Chlorine Dioxide								
Washer								
Hood	1	..	..	..	..	..	..	..
Duct	1	..	..	..	..	..	..	..
Exhaust fan wheel	..	..	..	..	..	..	1	..
Housing (inside)	..	..	..	..	..	..	1	..
Recausticizing								
Intake	..	..	1	..	..	..	..	..
Duct	..	..	1	..	..	..	..	..
Fan wheel	..	..	..	..	..	..	..	1
Lime Mud Filter Room								
Penthouse	..	..	1	..	..	..	..	..
Intake	..	..	1	..	..	..	..	..
Fan wheel	..	..	1	..	..	..	..	..
Duct	..	..	1	..	..	..	..	..
Boiler House								
Intake	..	..	..	..	..	1	..	..
Duct	..	..	..	..	..	1	..	..
Fan wheel	..	..	..	..	..	1	..	..
Woodroom								
Intake	..	..	1	..	..	..	..	..
Duct	..	..	1	..	..	..	..	..
Fan wheel	..	..	1	..	..	..	..	..
Machine Room								
Intake	..	..	1	..	..	..	..	..
Duct	..	..	1	..	..	..	..	..
Fan wheel	..	..	1	..	..	..	..	..

is present. Aluminum finds ready acceptance for enclosing all driers excepting the vacuum type. See Table VII for details.

RECAUSTICIZING

Classifier (slaker): Impeller, shaft, lining of mixing tank rake stringers, rake blades, rear rake hanger, overflow trough—all type 316 SS. Tank mild steel—no corrosion allowance
Causticizer tanks: Steel
Lime mud storage: Steel
Drive: Enclosed in cast meehanite housing
Lime storage: Steel—no corrosion allowance
Green liquor storage: Steel 1/8 in. corrosion allowance
Green liquor clarifier: Steel
White liquor clarifier: Steel
White liquor storage: Steel corrosion allowance 1/8 in.
Lime mud filter:
Drum ..... Cast meehanite
Heads..... Cast meehanite
Trunnions ..... Cast meehanite
Drainage ..... Cast meehanite screens
Bands..... Type 316 SS
Cloth..... Type 316 SS
Vat..... Shell and head mild steel, drum drive cast meehanite worm gear
Lime transfer equipment:
Knuckle chain.... High-carbon alloy steel
Buckets..... Malleable iron
Bearings..... Bronze bushed
Elevator casing... Steel (asbestos joints)

PRECIPITATOR

Wet bottom type: 8-in. acidproof hollow tile vat with lumnite mortar joints
Shell, type 316 SS
Collecting electrodes, 18 gage steel wire
Discharge electrodes, no. 430 SS with C.I. wts.
Dry bottom type: Shell, 8-in. acidproof hollow tile with lumnite mortar joints
Collecting electrodes, 18 gage steel wire
Discharge electrodes, no. 430 SS with C.I. wts.

EVAPORATORS

Shells: Mild carbon steel except upper portions of nos. 1 and 2 effect extending into vapor body which is 20% type 304 clad SS
Tube sheets: Mild carbon steel except nos. 1 and 2 effects which are 20% type 304 SS clad
Tubes: All seamless mild carbon steel except nos. 1 and 2 effects which are type 316 E.L.C. and welded into tube sheet
Flash tanks:
Condensate—Mild carbon steel
Liquor—304 SS
Vapor bodies:
Shell and head—Mild carbon steel
Deflectors—Carbon steel except lower portion of nos. 1 and 2 effects which is 20% 304 clad SS
Separators: Mesh—Stainless steel mesh pads

RECOVERY

Smokestack. The older kraft pulp mills built tremendously high stacks presumably to gain draft for the combustion equipment. In reality they served to vent the obnoxious odors and accompanying solid chemicals over as wide an area as was economically feasible. Modern mills are more efficient in both odor abatement and chemical recovery. Material specifications for a satisfactory recovery boiler stack are as follows: outer ring, reinforced concrete having a compression strength of 4000 p.s.i.

Inner lining of brick laid up in Penchlor chemically setting acidproof cement and free floating from the concrete exterior shell and reinforced with $3^3/_8$-in. steel bands. Both rings are capped with cast iron held on with stainless steel bolts anchored into the cement ring. Vent doors in the lower section of concrete stack allow air to enter and circulate upward between the rings thus cooling the brick lining. Four-inch concrete slab forms the floor. Expansion of the two self supporting stacks is completely unrestrained. Stacks built in this manner operate with a minimum of attention.

Table VIII. Sewer Pipe

Service	*Cast iron*	*Precast concrete*	*Vitrified time*	*Polyester resin fiberglass reinforced*	*Type 304 SS*
Domestic	1	..	..	..	..
Storm sewer	..	1	..	..	..
Manholes	..	1	..	..	..
Alkali					
Buried	..	..	1	..	..
Surface	..	..	..	1	..
Acid	..	..	..	1	1
Roof drains down pipes	1	..	..	..	..
Roof hoppers	..	..	..	..	..
Floor gratings	1	..	..	..	..

ELECTRICAL

If the mill power is supplied by an overhead transmission system, it is desirable to have two lines and two banks of transformers each capable of supplying the full mill power requirements.

Towers and hardware in the mill area should be heavily galvanized. Galvanizing has proved a satisfactory form of cathodic protection for this service.

Radial feeders from the main mill substation to the departmental power transformers are of armored-type cable and either underground or indoor on trays.

Motor control centers house all motor starters, power and control cables are D.S.T.A. armored and carried on elevated aluminum trays. This type of construction has many factors in its favor; savings in time, space, and cost, with an excellent service record for pulp mill use. A very limited number of motor drives, particularly in the machine room have conduit and cable runs.

Motor reliability is a major factor in pulp mill operation. Moisture and chemical fumes are sometimes present so that the motor windings are subjected to conditions not compatible with good electrical performance. In larger motors using form-wound coils the use of modern insulating materials comprising polyester and epoxy resins and silicone rubbers results in an insulation providing at least 50% greater dialectic strength for both class "A" and class "B" insulations. For smaller motors using random-wound coils the use of silicone rubber and epoxy resins has resulted in windings that are generally impervious to moisture and chemical attack. Many installations that previously required totally enclosed fan cooled motors can satisfactorily use drip-proof motors with this type of insulation. The use of such motors results in several economies: (1) the service factor is higher, (2) first cost is lower, (3) maintenance when necessary is simplified, (4) physical dimensions are minimized, and (5) fewer spare motors are required. Since the number of frame sizes is less than is true with a mixture of totally enclosed and open motors.

Motors so insulated and protected will give service under adverse operating conditions that is revolutionary. I strongly urge careful consideration of motor specifications as a major factor in reducing mill downtime and in lowering electrical maintenance charges.

SEWERS

See Table VIII.

INSULATION

This is an extremely important subject in pulp mill design, especially in those mills located in areas with high extremes in temperature between summer and winter. Pulp mills from the interior of British Columbia to the Atlantic Coast of Canada will have steam requirements between summer and winter varying by as much as 20%. For a 500-ton per day bleached pulp this figure represents a maximum of 1,500,000 lb. of steam per day. Assuming an average fuel cost of $0.50 per 1000 lb. of steam, the cost of heat loss comes to $750 per day for subzero temperatures.

For classes of insulations find general use:

1. Roof decks where some traffic is inevitable; rigid board of required thickness with a vapor barrier on the underside proves most satisfactory under built up asphalt and gravel roofing.
2. Applications protected from the weather such as tanks or vessels—fiberglass, mineral wood, or foam glass.
3. Steam piping where the use of a semirigid insulation is sometimes preferable—85% magnesia block. Broken up blocks are used to mold in flanges and this makes a good workmanlike job.
4. Antidrip insulation for cold water lines—cork compounds.

Aluminum sheathing over larger vessels and piping is extremely satisfactory where no caustic is present though the cost is high. This is common practice in the European mills and has an exceptionally fine appearance, but it is unlikely that it can be justified for general use because of the cost.

PAINTING

Surface protection by use of organic coatings serves two purposes: The aesthetic property and the functional property. The engineer is generally interested in the protection end because if the item fails prematurely the amortized costs are in error and reflect on his basic design.

With film protection, great emphasis must be placed on the surface preparation. If rust, grease, or scale is present, the paint cannot bond to the material. The most effective surface preparation is by sandblasting. This procedure is often impractical and hence some compromise is resorted to; acid cleaning—hydrochloric, sulfuric, or phosphoric acid attack the metallic oxides on metal and even etch the metallic surface itself. If grease or oil films exist, the acids are ineffective and these must be removed with other agents such as varsol or any of the existing detergents. Generally, items cannot be immersed or sandblasted so hand cleaning with solvents and wire brushing is the basis of most surface preparation.

In a pulp mill, by far the majority of surfaces to protect are steel. The action to be resisted here is iron in contact with water or humid air as it reacts to form ferric hydroxide. If the moisture can be excluded by a protective film, no corrosion will result. If an oil-base primer is used they are compatible with iron oxide and good bonding results even though the surface is not completely clean of rust. The use of a good primer followed by one or two finish coats to add body and a continuous film generally gives satisfactory service.

There are many paints available for specific purposes. Modified phenolic and drying oil form the basis of many hard surface enamels. The alkyd group of resins give glossy weather resistant surfaces. The epoxies have remarkable characteristics and are resistant to both alkali and acids. The list goes on and on. Vinyls, melamines, rubbers, urea and formaldehyde, polyurethans, acrylics, phenals, bitumals, etc.; all have individual characteristics and the engineer can find a coating that is serviceable under most conditions found in a bleached kraft mill.

This completes a general list of specified materials for major items of equipment in a modern bleached sulfate pulp mill, where quality and cleanliness dominate the operations.

Presented at the 15th Engineering Conference of the Technical Association of the Pulp and Paper Industry, held in Jacksonville, Fla., Oct. 24–28, 1960.

Radiant Heating—Its Characteristics, Generation, and Application

FRED J. PRINCE, OWEN R. WAGNER, and EDWIN S. MACK

The scope of this paper is to introduce and define radiant energy and describe the commonly available sources of this energy. The paper includes a brief transition into the mathematics of heat transmission and the nature and determination of heat exchange by radiation.

It is shown quite definitely that gas-generated infrared has a distinct advantage over infrared generated by electricity in the processing and drying of paper.

The advantages of direct fired radiant heaters are shown, with a discussion of proper installation methods, economics and results. Some case histories are discussed with a view to encouraging further research and study into the applications available to the paper industry.

A method of measuring the temperature of the moving webb is shown, together with a demonstration of the effect on paper of both near and far infrared waves.

You are all familiar with the three modes of heat transfer. They are (1) conduction, which involves transmission of heat through opaque solids, (2) convection, wherein the transfer of heat utilizes a fluid as the medium, and (3) radiation, wherein the heat is transferred in a form of electromagnetic wave motion. Radiation does not require any medium for transfer and the medium through which it passes is not heated. Radiation exists at all times between two bodies of dissimilar temperatures, but we will deal primarily with the radiant energy that falls within the infrared range on the electromagnetic spectrum. Infrared energy is similar to light, wherein it travels at the speed of light and can be reflected and refracted.

The most common example of this form of heat transmission is the passing of the sun's heat to the earth. This can be demonstrated best by a simple everyday experience. If one stands before a fire or hot radiator, he experiences a sensation of warmth that is not due to the temperature of the air; for if a screen is interposed, the warm sensation immediately disappears. This would not be the case if the air had a high temperature.

All bodies continually emit and absorb radiant energy in varying degrees. Primary factors influencing this change are surface temperature, surface condition, surface area, distance between bodies, and the characteristics of intervening media.

Current interest in infrared has resulted in many types of infrared generators. Basically, they can be divided into two general classes: those generating infrared using gas as a fuel and those generating infrared using electricity as a fuel. At the present time, the gas fired generators fall into one of four types: (1) the radiant tube burner (Fig. 1a) where the gas-air mixture is fired into a tube, the surface of which becomes the radiator; (2) surface combustion burners (Figs. 1b and 1e) which utilize a porous refractory for the radiating surface on which a gas-air mixture burns, creating the radiator. Into this same group would fall drilled port ceramics, metallic screens, and drilled stainless steel; (3) direct fired refractory burners (Fig. 1c) which utilizes the impingement of the gas flame on the refractory and produces the highest intensity radiant flux; (4) catalytic burners (Fig. 1d) that use a catalyst to oxidize gas at low temperatures.

Those using electricity for the generation of infrared also fall into four categories: (1) the infrared lamp (Fig. 2) which is a short wave emitter, (2) radiant rods (Fig. 3) which uses

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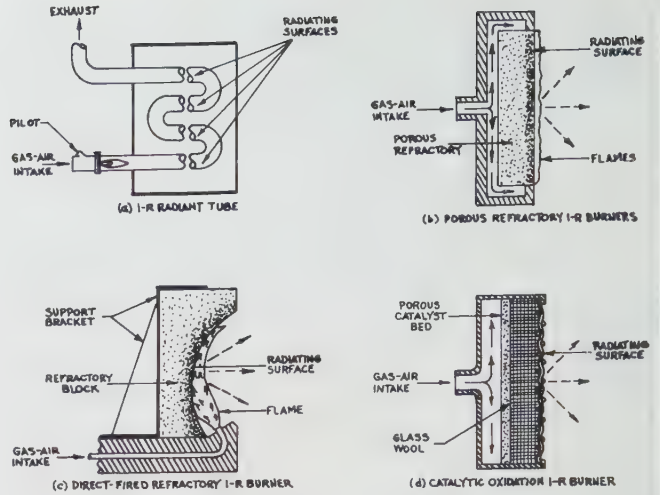


Fig. 1. Four different types of gas-fired I-R burners

the principal of resistance to heat tubes to approximately 1500°F., (3) quartz tubes (Fig. 3) which use a relatively low temperature nichrome wire filament to heat the quartz, (4) quartz lamps (Fig. 3) which use a fused translucent quartz heated by high temperature tungsten filaments.

Infrared or radiant heating, is not a modern miracle in any assumption that it provides something for nothing. It takes approximately 1100 B.t.u.'s to evaporate a pound of water under average conditions. We cannot change physical laws and therefore, this net amount of heat must be delivered to the material being dried and the water being evaporated. Under practical drying conditions, 40 to 50% efficiencies

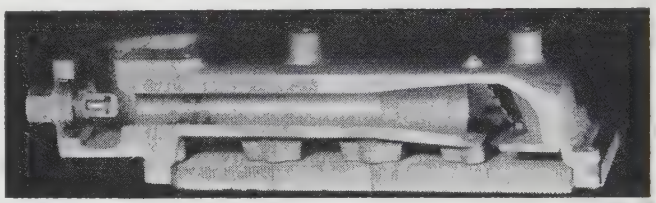
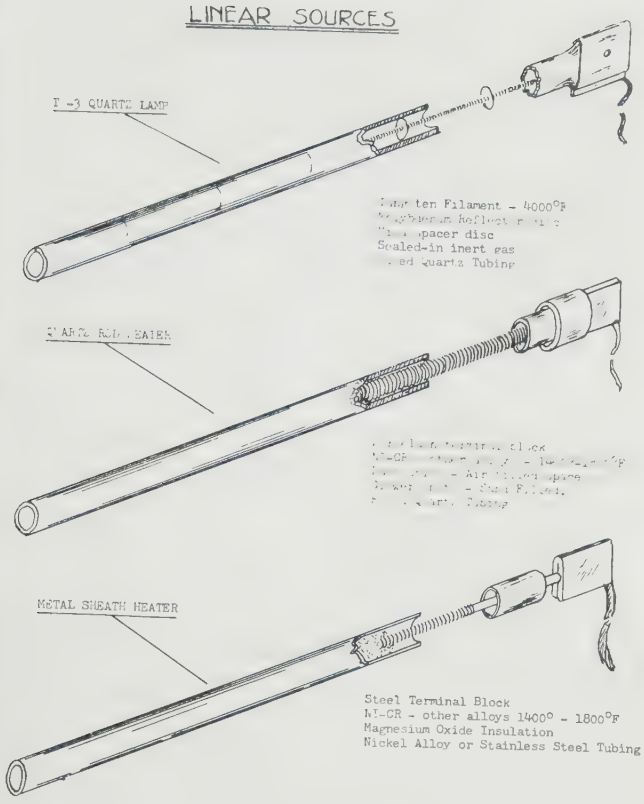


Fig. 1e

can be considered good, so that an average input of 2500 B.t.u. to the drier, per pound of water removal required, is conservative. This input is at the drier and does not take into account—transmission, generation, and other losses that are encountered when the heating medium is steam. This fact provides one of the major advantages of radiant heat; a lower operating cost. Radiant heat has the additional advantages of providing increased speeds on existing equipment without increase in labor cost or additional excessive investment. Radiant heat offers a convenient and efficient means of drying and it is easily controlled by automatic devices. In plants where boiler capacities are being taxed, radiant heat can provide the answer to the question of increased capacities with minimum outlay.

Our aim is to show the how and why of infrared energy, and more precisely how it can be applied to the processing of paper.

Fig. 2


LINEAR SOURCES
T -3 QUARTZ LAMP
Steel Terminal Block
Ni-CR - other alloys 1400° - 1800°F
Magnesium Oxide Insulation
Nickel Alloy or Stainless Steel Tubing
METAL SHEATH HEATER

THE FOSTORIA PRESSED STEEL CORPORATION
Fostoria, Ohio

Fig. 3

The ASHRAE Guide Book defines radiation as the transmission of energy by means of electromagnetic waves. There are many types of radiation, all of them being members of the electromagnetic family. Figure 4 indicates various types of these waves and shows how they are classified by wavelength.

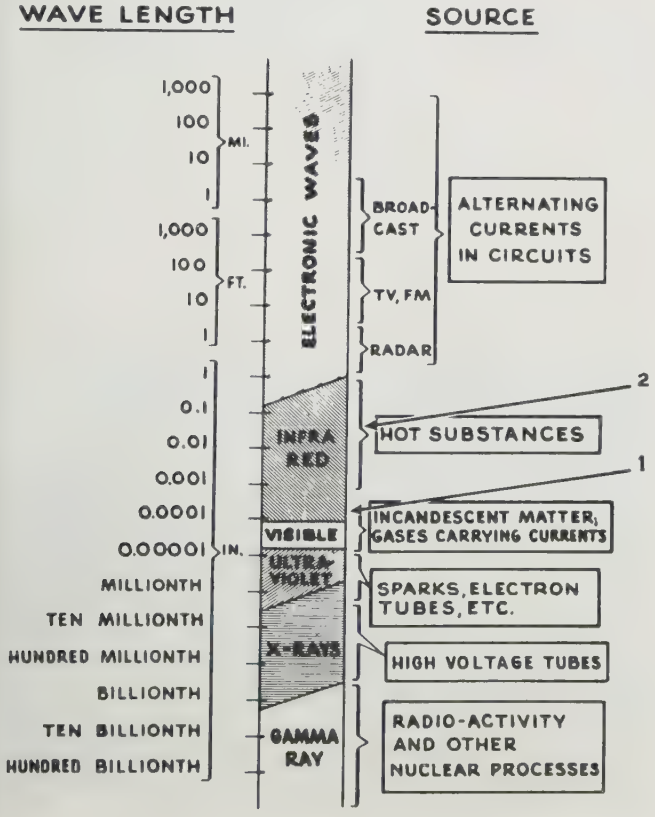
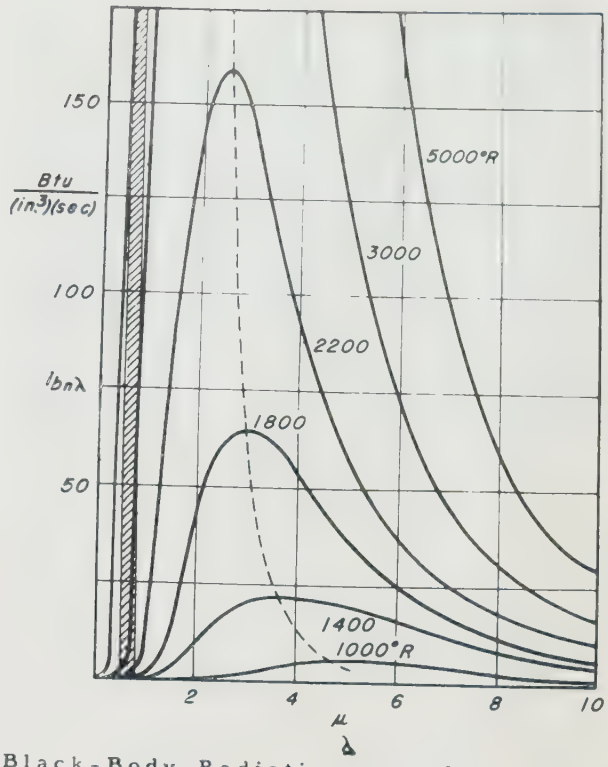


Fig. 4



Black-Body Radiation as a function of Wavelength for Different Temperatures

STEFAN BOLTZMAN LAW $e_b = \sigma T^4$

WIEN'S DISPLACEMENT LAW $\lambda_{max} = C/T$

PLANCK'S EQUATION $i_{\lambda bn} = \dfrac{C_1}{\lambda^5(e^{C_2/\lambda T}-1)}$

Fig. 5

Infrared waves fall into the range of 0.7 to 100 μ. Any radiating body will produce a variety of wavelengths. This is illustrated quite well in Fig. 5, which contains several plots of black body radiation as a function of wavelength for different temperatures.

Black body values are shown because their characteristics are known with extreme accuracy. A black body by definition is a perfect radiator. However, it does not mean that the color must necessarily be black. In fact, snow is very nearly black to infrared radiation from a body whose temperature is not too high.

A black body radiates heat in a wide range of wavelengths. The maximum value for the radiation intensity moves with increasing temperature to shorter wavelengths. This is described by Wien's law:

$$\lambda \max = C/T$$

where:

λ max = wavelength for the maximum radiation intensity
C = constant
T = absolute temperature

The visible range of wavelengths is indicated in Fig. 5, as a shaded band. It can be seen that with increasing temperature an increasingly greater part of the whole radiation falls into the visible range. At 1800° R the small radiation in the visible range is seen as dark glowing red. Even at 5000° R the visible part is comparatively small and the radiant energy is almost completely contained in infrared rays.

Total energy radiated by a black body is given in Fig. 5 by the area under the curve. This is also stated by Stefan Boltzmann law

$$E_b = \sigma T^4$$

where σ is the Stefan Boltzmann content.

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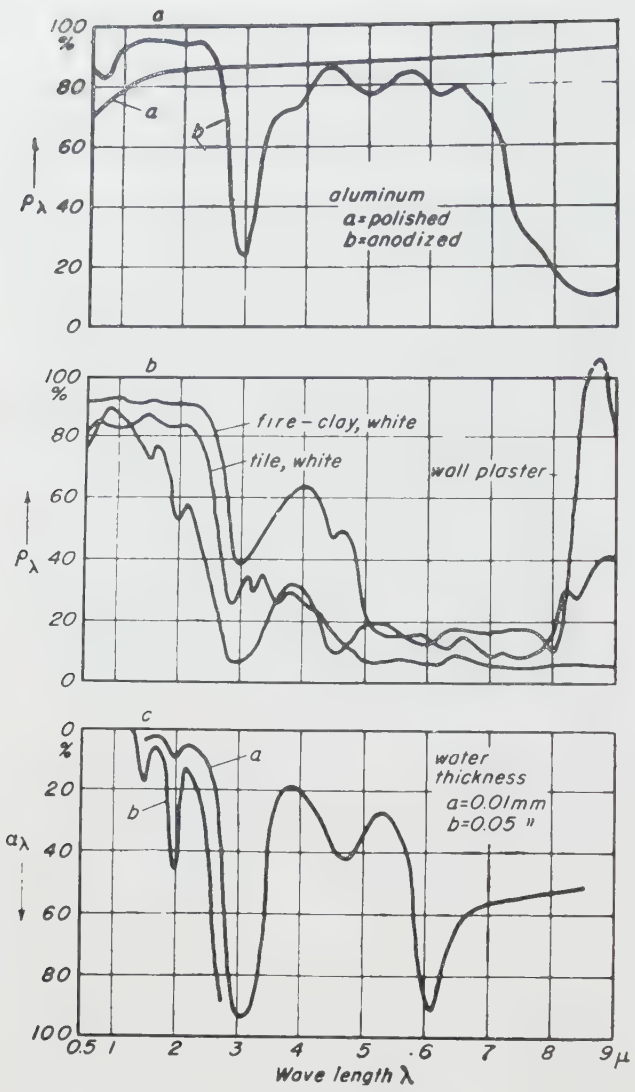


Fig. 6

Planck's equation is also given in Fig. 5 and this equation gives the plot of the curves shown.

For this discussion, near infrared will be defined as those rays falling in the range of 0.7 to 1.5 μ, and far infrared as those in the 1.5 to 100 μ range. From our previous discussions it is evident that near infrared is produced by high-temperature sources and far infrared is produced by lower temperature sources.

When infrared strikes an opaque object, some of it is absorbed and some is reflected. Certain materials, such as glass, will transmit a portion of the energy. The portion of the energy absorbed determines the absorptivity of the material.

The ratio of the total emissive power of any body to the total emissive power of a black body, at the same temperature, is called the emissivity and is numerically equal to the absorptivity. Emissivity generally increases with the increase of temperature.

If there is no transmission of infrared energy, then the per cent that is not absorbed is termed the reflectivity. The sum of absorptivity and reflectivity must equal *one*. Reflectivity is dependent upon the character of the surface. In general, metals with highly polished surfaces are good reflectors, and nonmetals are usually poor reflectors.

Figure 6 portrays the reflectivity and absorptivity for several materials. It can be readily seen that the majority of these items absorb a greater percentage of the longer rays or far infrared energy. This characteristic illustrates why the far infrared sources are highly efficient in the field of drying and heating.

In any practical heat exchange problem all three modes of heat transfer are in effect. However, with heat sources having relatively high surface temperatures convective and conductive forces may play minor roles.

In a solid body the flow of heat is the result of the transfer of internal energy from one molecule to the other. This process is called conduction.

In liquids and gases, motions of a microscopic nature may exist and heat may be transported from one point to another by being carried along as internal energy with the flowing medium. This process is called heat transfer by convection.

Several factors must be considered in computing heat exchange by radiation. The formula generally used is as follows:

$$q = \sigma F_a F_e A_1 (T_1^4 - T_2^4) \text{ B.t.u./hr.}$$

where:

σ = Stefan Boltzmann constant
F_a = shape factor
F_e = emissivity factor
A = area of high temperature source
T_1 = absolute temperature of high temperature body
T_2 = absolute temperature of low temperature body

The shape or configuration factor gives the portion of the total energy emitted by the high-temperature body that falls on the low temperature body. These factors can be determined mathematically and at best is a tedious chore. Many texts provide curves or tables supplying these factors. Sizes, attitudes, and separation of bodies involved are considered in determining the factors.

Fe or the emissivity factors are also given in the texts.

In any attempt to solve a practical problem in radiant heat exchange, it is well to verify answers with a pilot test.

RADIANT ENERGY PRODUCTION AND GENERATING EQUIPMENT

The sources of radiant energy as previously mentioned, embody every object having a temperature above absolute zero. As mentioned before, the sun is the most commonly known source of this energy and its affinity for moisture is a phenomena not fully understood by those who have not studied infrared energy. It was also mentioned before that the man made sources of infrared were energized by either gas or electricity. A brief discussion (and equally a brief dismissal) of infrared as generated by electricity, is propitious at this time. The advantages of electrical devices are simplicity of operation and control, and the high efficiency in the utilization of input. The disadvantages range from the fact that the bulb and tube-type generators are highly susceptible to breakage, to the high cost of operation, their poor shape factor, and the fact that high temperature filaments produce near infrared and therefore are not suitable for

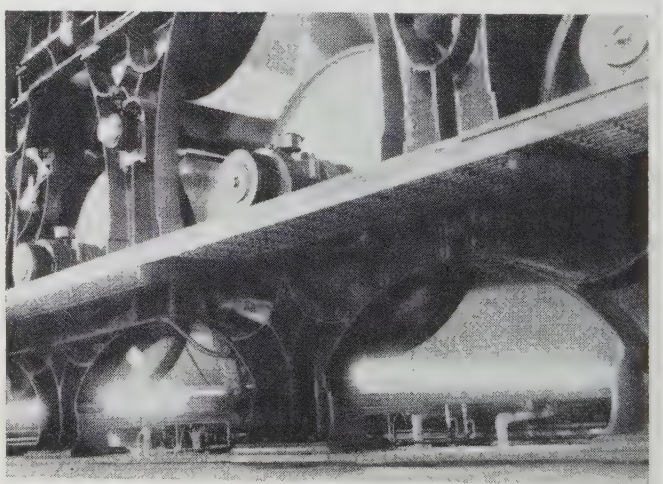


Fig. 7

heating any material whose reflectivity is high in the near infrared range. A study of Fig. 6 shows clearly the expected results when subjecting water to near infrared at 1 μ wavelength or below. When the four types of electric generators were defined, it could have been pointed out at that time that the infrared lamp is very definitely in the short wave field. The radiant rods, or resistors, have all the disadvantages of gas fired radiant tubes, neither of which have a real application in paper processing. The quartz tube has a proper wavelength, but requires reflectors and has a relatively poor shape factor. The quartz lamp is a short wave emitter and for all practical purposes is not suitable for paper processing. Note that all cylindrical generators require highly efficient reflectors in their applications.

It was previously pointed out that a net input of 2500 B.t.u. was required as an input to the drier, to evaporate 1 lb. of water. In terms of electricity, this represents 0.732 kw. If we speak in terms of a thousand pounds of water, we are comparing 2500 cu. ft. of natural gas with 732 kw. of electricity. Electricity at T.V.A. rates of 4 mills per kw. would cost $2.928 for the 732 kw. progressing up in cost to .0025 per kw. for a cost of $18.30 for the kw. Natural gas rates run from 30¢ per 1000 cu. ft. to $2.00 per thousand, making the equivalent cost of gas range from a low 75¢ to a high of $5.00. In most areas the rates are relative and in applying local rates it will be found that the electricity will cost, as an average, $2^1/_2$ times the cost of gas.

Natural gas has a nominal heating of 1000 B.t.u. per cu. ft. and the liquefied petroleum gases range from approximately 2500 B.t.u. per cu. ft. for propane, to approximately 3000 B.t.u. per cu. ft. for butane. These values are mentioned to provide a better understanding of the air requirements for proper combustion. A good rule of thumb is that it requires 2 cu. ft. of oxygen (the amount of oxygen present in 10 cu. ft. of air) to support combustion efficiently for 1000 B.t.u. of gas. This air can be supplied as all primary air by the mixer, or partially secondary air at the burner itself. This fact is of major importance inasmuch as egress for this air must be provided in the building, room, or area in which the installation is to be made.

A brief summary of the available types of gas infrared generators was given earlier. A further discussion of these types will assist in narrowing down the choice of type for any given application. The radiant tube is an internally fired unit. The units may be tubes or panels and may be metallic or ceramic. They may operate at temperatures from 700 to 2500°F. and find their best field in ovens or in the presence of generated atmospheres where contamination is undesirable. Their shape factor normally does not warrant their use even with reflectors, for high speed drying.

The surface combustion infrared burners are normally a flat plane, providing a desirous shape factor. A porous material which can be a metal plate, a metal screen or ceramic, provides the surface for the completion of the combustion. The

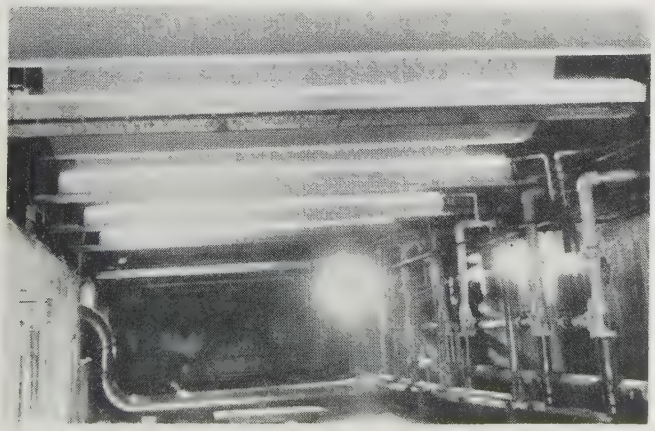


Fig. 8. Red-Ray burners installed under steam driers

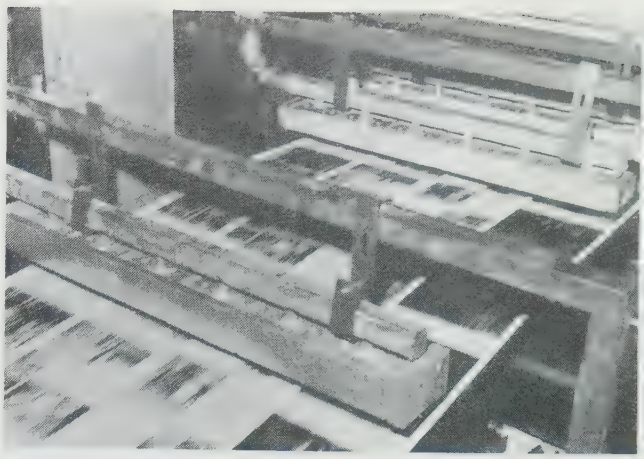


Fig. 9. Red-Ray burners used in ink drying on high speed magazine work

surface itself becomes the radiator, and because of its temperature range, which is in the neighborhood of 1500 to 1800° F., its peak wavelength is close to 3 μ, which is the most desirable level, as previously shown. These burners can be manifolded into any desirable configuration, and are practical in drying processes.

The radiant fired refractory unit is heated directly on its surface by the impingement of the flame. The temperature of this type burner approximates 2800°F. and its peak wavelength would approach about 1.6 μ. Its black body emissivity would be about 220 watts per sq. cm., providing an extremely high flux density. These burners can be manifolded into any desired length and provides desirable flexibility in inputs.

The low temperature catalytic units are atmospheric burners and have face temperatures of approximately 650°F. Their peak wavelength is about 4.5 μ and for this reason have a field of acceptance more in comfort heating than in processing.

General Electric has created a radiation calculator which can be used for determining the wavelengths of a radiator at various temperatures. Emissivity factors of various surfaces and materials, can be obtained from several handbooks. A more thorough study of infrared energy can be obtained from the A. G. A. Laboratories, Research Bulletin No. 83. This bulletin also contains a comprehensive literature review and its study is recommended for those desiring the further pursuit of the applications possible with infrared or radiant heat.

Installation standards require that certain controls and safeguards be installed. In all cases, to obtain the maximum efficiency and results, it is necessary that the air and gas delivered to the burner be premixed. This can be accomplished by two methods. One is a compressor-type mixer wherein the gas and air are drawn into the compressor, at a proper ratio, and delivered under pressures varying, normally, between 1 and 2 lb. to the burner manifold. The other method is to utilize a centrifugal compressor to deliver air to a venturi mixer at which point the kinetic energy of the air is used to entrain atmospheric pressure gas (zero) and deliver the resulting mixture to the burner manifold. In either case, a single valve can control the quantity of mixture delivered.

In the discussion of the determination of heat exchange by radiation, only the radiation component was given consideration. Due to the fact that convected heat is also available, the maximum efficiency for drying at the wet end can be attained by placing the burners face up under the web. Figure 7 shows a typical installation. Note that the surplus heat aids the drying on the upper section of the stack.

The burners are ignited by a pilot which can be constant or intermittent. The pilot itself is normally ignited by an electric spark, when automation is desired. It is essential

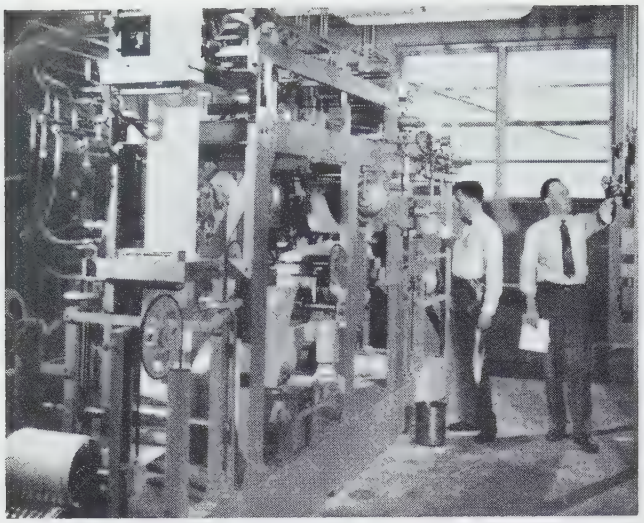


Fig. 10. Red-Ray burners on experimental coating machine used in research lab of one of the large paper companies. Two Red-Ray burners are applied to each side of the paper

that the pilot flame be monitored and this can be done with any of several electronic combustion safeguards available. In case of pilot outage, a manual reset safety shut-off valve is tripped, shutting off the flow of gas to the main burners. Note that whereas the gas is shut off, air continues to flow to the burners, thereby cooling them to prevent scorching of the web. In addition, the following controls are recommended: (1) a tension switch bearing lightly against the upper or lower side of paper, which will turn off burner if paper sags or breaks; (2) a relay interlocked with the electric contactor of the drive mechanism to prevent burner operation when the drive stops; (3) gas pressure switches to shut off gas valve if gas pressure drops or rises excessively due to regulator trouble; (4) an air pressure switch to shut off gas in event of combustion air blower failure or air pressure drop; (5) an air flow switch in the exhaust hood, if positive exhaust is used, to act as a purge delay and control against exhaust fan failure; (6) a centrifugal switch to turn burners off when paper is slowed down below a specified speed; (7) a motorized butterfly valve of the potentiometer type to modulate the burner input when instrumentation is used; (8) an electric eye to spot breaks and shut off burners.

Burners installed using the recommended controls are safe and efficient.

The advantages of gas infrared production versus electricity and other means, will become quite apparent as discussions of applications and case histories are developed. No one is primarily concerned with the glamour of infrared unless it is practical in production; and while theories sound good, they too are worthless unless practical. The reason for confining the balance of this discussion to gas infrared is due to the fact that gas provides an inexpensive, flexible fuel and that the installation of gas burning equipment requires little more than common sense. Furthermore, much has been learned of its true nature, by means of case histories. Dealing with a known quantity provides an opportunity to speak with authority.

It has already been stated that the primary factors influencing the absorption of radiant energy are surface temperature, surface condition, surface area, distance between radiator and absorber and characteristics of intervening media. In the application of radiant heat to drying paper, these factors are either naturally advantageous or through proper installation can provide maximum benefits.

We are concerned with the difference between the fourth power of the absolute temperature of the radiator and the fourth power of the absolute temperature of the absorber. In drying paper these factors are almost at a maximum desirable condition with both the low temperature paper and the high temperature radiator in a relatively steady state.

Surface condition refers primarily to the emissivity factors of the radiator and absorber. A heat exchange equation contains as a factor the product of the emissivity for each body. Obviously, the higher this factor the greater the exchange. The factor for white paper is 0.94 and for water 0.96. Gas fired infrared generators have emissivities ranging from 0.69 to 0.82. The resulting product of these factors contributes to the high efficiency of this drying method.

PAPER DRYING

The drying of paper has not progressed very far. It reached a dormant state many, many years ago after the development of the steam cylinder drier. This drier served a purpose, then and now, not only in the drying of the web but also in maintaining a relatively even or smooth web.

The only major improvements in paper drying have been made very recently. First in the application of radiant or infrared burners and, more recently, in the use of high velocity, high temperature air driers. Both have done an excellent job.

The smoothing factor of a steam cylinder drier cannot be discounted. Some means of maintaining an even web is required, consequently this type drier cannot nor will not be discarded in the foreseeable future. As a drying medium, however, this steam cylinder is most inefficient. Let us analyze its operation. Common sense will show us how inefficient it is without the necessity of looking at long established efficiency tables on this type of drying. First, fuel is consumed in a boiler. The heat of combustion is then transferred through the boiler walls and tubes into the water contained therein The water is heated to the point where it vaporized under pressure. The water vapor (steam) is then transferred through piping from the boiler to the driers of the paper machine. These driers are then heated by this steam, the heat of which is conducted through the cast metal walls and ends of the cylinder to heat the web of paper which covers approximately two-thirds of the sides of the cylinder—the other one-third and the ends heat the surrounding air. There you can readily visualize the inefficiencies resulting from all of the transfers of B.t.u. resulting from the original combustion of the primary fuel. To determine an overall efficiency it would be necessary to first determine the efficiency of the boiler (B.t.u. of fuel input versus B.t.u. of steam available for transmission). Next the efficiency of transmission with heat losses (B.t.u. delivered from the boiler versus the B.t.u. delivered to the driers). Next the efficiencies of the driers themselves (B.t.u. input versus pounds of water removed from the web). All in all you'll probably find an average efficiency on this basis to be in the neighborhood of 25 to 30%.

Next let us see just why the steam driers are slow. Visualize the hot drier face, a wet web covering it. This web is heated in the inner face, the temperature of the inner face is (depending upon steam pressure and the rate of transmission thru the walls) in excess of 212°F. Therefore, the water in the web in contact with drier face is brought to a boil (to a vapor state). If at this point the web were opened and the air surrounding the web was at a temperature high enough to keep the moisture or vapor from condensing, all of this moisture which was brought to the vapor state would be released and carried away from the web. However, this is not the case. What actually happens is that the water in the web is heated to the vapor state where it is trapped by being in contact with the drier face. Thus the water vapor is forced through the web to escape on the exposed surface. During the first drier stages this also serves to heat the web all the way through but in accomplishing this, it also serves to condense the vapor back into water again within the web. Of course some vapor is released on the free side of the web. In its progression from one drier to another the web is cooled

as it reaches the open spaces between driers and then must be reheated again—repeating this cycle throughout as many driers as there are in the drier section of the machine. Of course the web is eventually dried—but at what efficiency and speed?

To assist the efficiency, a warm air system (usually in the neighborhood of 160 to 180°F.) was introduced to surround the driers in order to keep the released vapors from condensing back on the web. This was a great help, and we have been told, usually added about 10% to the drying capacity of the machine. You can readily see that the more practical approach to the drying of paper would be to evaporate from its exposed surface rather than its concealed surface.

The use of a radiant or infrared gas burner in paper drying was pioneered quite a few years ago. The first installation of any consequence was made on a roofing felt machine. This initial application, while crude by today's standards, increased the capacity of the machine by 18%. Since the initial installation of six burners, six additional burners were installed. This original installation was made in 1946 and it is still in operation today.

Since that time literally hundreds of installations in paper mills have been made throughout the world. The basic idea was the same—to apply heat to the exposed web permitting unrestricted evaporation. Let us explore just how this system works and why it is efficient: I will not repeat the glamorized stories concerning the radiant heat from the sun, its passage through millions of miles of space in the form of a ray to the earth where upon striking an object it transforms itself into heat-energy. Nor will I at this time regale you again with the value of varying wavelength microns. All of this you have heard many times before. When glamorized it will interest the layman and when delved into, will interest the scientist. That which interests the engineer is a little bit of "what is it?" A lot of "how do I apply it?" and a lot more of "what will it do for me?" The economist is interested in "how much does it cost to purchase and install," and "how much does it cost to operate per ton of paper obtained?"

Let's see if we can answer those questions. First, the radiant (infrared) burner is basically a distribution tube with holes in it that takes a mixture of gas and air, releases it to atmosphere where it is ignited and burns. This then is similar to your cook stove at home, the bunsen burner in your laboratory or the burner in your boiler (and I do mean your boiler) for whether you use gas, oil, wood, or coal, the fuel must first be converted into a gaseous state before it will burn.

The infrared burner has certain refinements over the gas burners such as the home cooking stove or bunsen burner just described. Here is what they are. First, a premix system is used. This means that both the gas and the air required for combustion are mixed under pressure, regulated, and delivered to the burner. Thus we are assured of proper mixture and uniform rate of flow. The burners are usually sections attached to a common manifold, designed to provide a unit of any desired length corresponding to the width of the web on the machine and assuring an equalized distribution throughout. Unique design of the ports of these burners (this is the area from which the gas is actually vented to the air and burned) further assures an equalized distribution, provides a burner on which flashback is virtually impossible to obtain. This provides an almost infinite ratio of turn-down or control. These burning gases cause the surface of this refractory to become incandescent, converting a major portion of the fuel into radiant (infrared) energy.

Heat, then, is developed for two methods of heat transmission, that of radiation and convection. The hot surface provides the radiation, the burning gases provides the convection.

Next, "how do we apply it?" These burners have been applied at many locations on a paper machine. They have been applied between presses to heat the web so that the viscosity of the water within the web will be reduced, permitting more water to be squeezed from the web in the subsequent press section. Burners have been applied between the last press and the first drier. This application brings the temperature of the water within the web to the vaporization point, thus permitting the first driers to begin an evaporation job (most drier sections use the first two or three driers just to bring the web up to this evaporation point). In addition, the preheating of the web eliminates the picking of the web on the first drier and eliminates the necessity of keeping a reduced temperature in the first driers as it is often done where no preheat is used. Burners have been applied under the bottom driers, between the driers and inverted above the tops of the driers.

This description of some ways to apply burners, has also indicated a little of what they will do. Perhaps an elaboration on this phase would be in order. It has been found that on an average installation, one burner of 50,000 B.t.u. is equal to one and one-third driers of equal length (drier face equal to length of burner) and at 60 p.s.i. steam in the drier, 48 in. diam. Thus it can be seen that the application of three such burners would be equal to the drying capacity of four driers. To put it another way, three rows of burners 144 in. long, each with an input of 1,000,000 B.t.u. will replace four cans 48 in. diam. and 144 in. long, operating at 60-lb. steam pressure. It has been stated that burners may be applied in several locations, and also that burners provide both radiation and convection forms of heat of heat transmission. Now, with radiation it is not important where the burner is placed; burning upward, downward, or on its side—as long as it is faced toward the web—all of the radiation which strikes the web will be converted into energy. True the intensity (temperature) is inversely proportionate to the square of the distance. Therefore, the farther away from the web, the lower the temperature. However, the heat volume remains the same—it is merely spread over a wider area. The second method of heat transmission—that of convection—must be applied with a little more thought to thermal dynamics if the ultimate in efficiency is to be obtained. It can be seen that if a burner is placed under a bottom drier both the radiation and products of combustion would strike the web. In addition, the products of combustion will circulate around the drier and up through the drier stack, maintaining a temperature high enough to maintain the evaporated moisture in a vapor state carrying it away from the drier section (if you can see visible vapor around your driers then you have moisture condensing back in the web). If conversely, the burners should be inverted over the driers, facing downward, the efficiency would not be as great, unless these products are picked up through a blower system or heat exchanger and redirected against the web. Burners applied between presses as a "hot press" have shown results equal to that obtained directly on the drier section. Actual evaporation at that point is less, but water removal by the press is greater and the web is warmer when hitting the first driers thus permitting the driers to do more evaporating.

Control of these burners has also developed tremendously in the past few years. On original installations there was a great fear by many of the operators of a fire hazard and an even greater fear on the part of the underwriters. This, of course, is understandable for we all know that paper burns. An incident that seems amusing when looked at now, was one of anxiety during a hassle with a large insurance group. Burners had been sold to one of the nation's largest producers of roofing felt. When these burners were in process of being installed, the field inspector for this insurance group took one look and threw up his hands in horror, called in his boss and then all hell broke loose. His boss in turn, called in brass from many sections of the country and everyone became

embroiled in verbiage that seemed, at the time, hotter than the burners themselves. The results of the discussions were that at the insistence of the customer, the burners would be permitted a few hours trial. The insurance group insisted that the town fire department, plant fire department, and all concerned be alerted for a fire. The great day was arranged and the burners started (there were six burners, one under each of the first six bottom driers). Here are the results of that run: First, the burners provided a 12% increase in drying capacity. Second, there were no fires—in fact, one of the insurance representatives took a piece of wet felt and draped it over the burning burner. All that happened was that the felt directly in front of the flame dried and burned and the overlapping edges dropped into the pit. In fairness to the insurance companies, their thinking was revised and observations made that day, resulted in the adaption of many safety practices recommended by them which are now incorporated into all applications made by reputable burner manufacturers. The controls used include combustion safeguards to monitor the burner flame. Some years ago combustion safeguards used for multiple burners were all tied into one main valve. Now, it is considered good practice to valve each burner separately for the reason that when multiple burners are used that will provide an increase in capacity of say 10%, should anything happen in the safety circuit to shutdown these burners, it would be virtually impossible to slow down the machine fast enough to prevent some wet paper getting through. When a separate valve is used on each burner, should something happen to shutdown a burner, the other burners would continue to operate, thereby eliminating the possibility of suddenly bringing unusable wet paper through the machine. Controls such as were previously described, should be used in addition to following all F.I.A. and F.M. recommendations. Maintenance of this equipment is at a minimum due to the rugged construction of both burners and control systems. Electronic control should be of a "plug-in" type so that it is unnecessary for the plant to have an electronics engineer maintain the equipment. Any electrician who can trace the external circuits through pressure switches, relays, and valve coils of a ladder-type drawing, can service the equipment. If the electronics part of the equipment is of a plug-in type, it can be replaced if defective, in but a moment's time.

To give you the exact cost of installation is a bit like saying "how long is a piece of string?" The cost of the equipment is dependent upon the number of burners, the length of burners, the control equipment required, the mixing equipment required, etc. However, you would like an idea. Completely safeguarded installations have been made on a paper machine for as low as $1000.00. The largest one was in the neighborhood of $30,000.00. The average installation that would provide approximately a 10% increase in drier capacity would run $6000 to $10,000. This is an average figure for an average machine of an average number of driers. The actual installation expense incurred by the mill would be the installation of gas piping to the machine, the mounting of the burners and blower, and the interconnection of piping from the blower and mixers to the burners and from the gas line to the control valves to the mixers. In addition, flame rods must be mounted on the burners and wired to the control panel. A power supply must be brought to the control panel and blowers and valves wired from this panel. The time, men, and material required, is again dependent upon the number and length of burners installed. The average time for an average installation, is usually about 3 to 4 days. The burners are usually installed during the regular down time for wash-up. The auxiliary equipment—blowers, wiring, etc., can be completed while the machine is running.

The next question of major importance is how much is its operating cost per ton of dry paper. Again the question "how long is a piece of string?" Obviously, this question can only be answered if certain factors are known and these facts are variable. First, the cost of fuel. The cost of fuel is dependent upon several factors, these being location, type of fuel, and quantity purchased. It is reasonable to assume that, just as with solid fuels, the greater the distance from the area where it is produced to the point of use—the higher the cost. In some areas of the country natural gas is the least expensive fuel. In some other areas oil is used. In some coal and wood are stil' used, although this type fuel for boiler operation in paper mills is fast disappearing. In the areas where gas is used as boiler fuel, there is no difficulty in evaluating the radiant gas burners. The mill operators are well acquainted with the fuel, and their long association with gas has caused them to respect it, but not fear it. The overall efficiencies obtained from a direct application are greater than the long and drawn out process of fuel input to the boiler to water removed from the paper "inefficiency." The best analogy is a comparison of the line shaft to the motor on each machine. In areas where gas transmission costs have raised its price to a point above that of oil, the mill operator matches dollar cost per ton of paper produced which, in some localities, will amount to more than his cost using oil in his boilers per ton of paper produced. Of course, the only way to determine what the cost would be at your mill would be to determine what your fuel costs would be. It is certain that you know what your steam costs are—your gas costs can be determined by inquiring from your local supplier his rates for industrial use. Obviously, the greater the quantity used—the lower the cost. Here is a comparison that you will probably find. One, that steam is generally computed to cost between $0.50 to $1.50 per thousand pounds (1,000,000 B.t.u.). Gas costs, in quantity use and depending upon location, from 3 to 20¢ per therm. A therm is 100,000 B.t.u., therefore 1,000,000 B.t.u. would cost from $0.30 to $2.00. You can see that gas is both cheaper and dearer than oil—depending upon the location. One paper mill has a 4000 CFH natural gas well right on its own property. The cost of this fuel is only the cost of piping it from the ground and maintenance of equipment. Add to these fuel costs the thought that the oil must be used in the boiler whereas gas is a fuel that can be utilized at point of use. It does not take much imagination to recognize how much the reduction in overhead, capital investment, and maintenance can profit your organization.

High velocity air driers were previously mentioned. This is the most recent idea to capture the attention of paper mill operators. Its theory is to heat air to high temperatures (usually by gas burners) and then blast it at high velocities against the web. These systems do a good job—there is no quarrel with them; however, it is interesting to note that they do only the same job that a radiant burner will do. First, the temperatures are high, in fact they are sometimes high enough to cause ignition of dry paper—so are the products of combustion of radiant burners. However, the fact that there is no actual flame present in the area immediately adjacent to the drier or the web alloys the fears of some individuals. The hazard, if any, is the same. Secondly, the high velocity drier uses its high velocity air to impinge this heated air directly against the web for the sole purpose of breaking through the insulating air barrier that surrounds all objects. Like the film of oil on a bearing which insulates the shaft from the bearing, there is an insulating film of air which insulates the web from the heat source. To overcome this insulating film the high velocity driers utilize their high velocity to penetrate this barrier. The radiant burner does it differently—to glamorize the rays of the sun, the millions of miles of space and the closed window—yet you still feel the sun's heat generated on the surface of your body. Such is the transmission of radiant heat from a radiant burner to a web of paper. The film of air has no insulating effect for an infrared ray. Therefore, heat from the radiant burner is generated within the web and the vapors released are carried

away by the products of combustion in a temperature maintained high enough to preclude condensation of those vapors on the web. Another advantage of the radiant burner is that while there is a velocity of air emanating from the burner, it is not high enough to disturb the formation of wet pulp or to cause streaking in a coated web. High velocity air driers require tremendous horsepower to create the velocity and volume of circulation required, utilizing B.t.u.'s not generally accounted for in determining the efficiency of this type drier.

SPECIFIC APPLICATIONS OF RADIANT HEATING IN THE PAPER INDUSTRY

So far the discussion has touched generally on radiant burners, their characteristics and general applications. No attempt has been made to specify types, nor can this be done in an understandable manner without dealing with specifics. By inference, the radiant tube and the low temperature catalytic burners, have been eliminated from consideration as far as their use is concerned in paper processing. Their position in the electromagnetic spectrum is not condusive to the rapid drying results that form a major part of the paper industry.

Narrowing the field down to two general types, helps narrow the choice of types. The surface combustion type burner, operating in temperature ranges of about 1500°F., provides a tool for drying coatings, inks, etc., at considerably slower

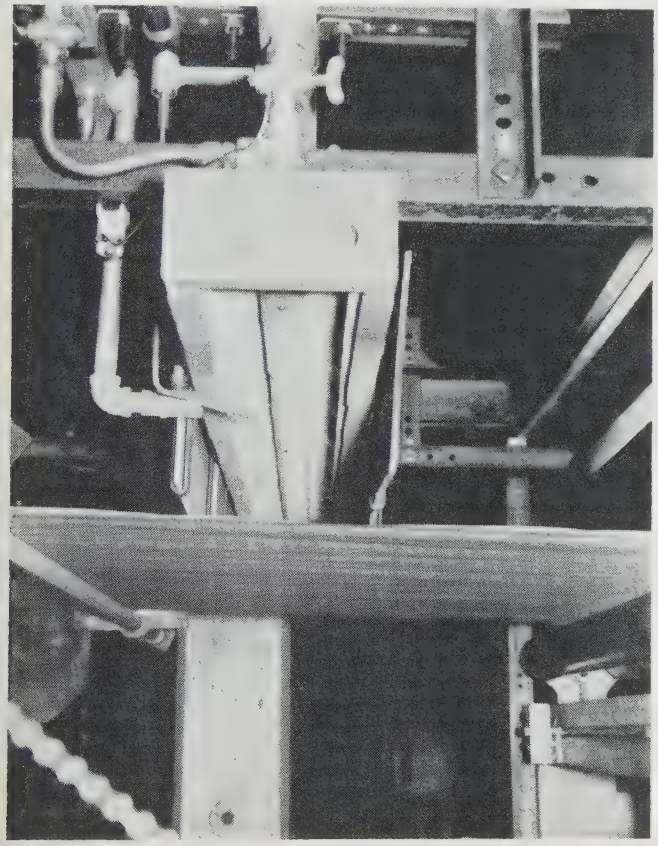


Fig. 11. Red-Ray burner applied to paper web drying silicone

speeds than those normally attained in manufacturing the original stock.

The direct fired ceramic burner, operating at temperatures of 2400°F. and above, do provide an answer to high-speed drying. Previously it was stated that engineers were primarily interested in a little of "what is it" and a lot of "how do I apply it" and a lot more of "what will it do for me?" Case histories of actual installations will go a long way toward the answer to the last two questions. The economics of "how much does it cost" will be disposed of later.

A plant in the west had a 102-in. Downingtown. The major products were meat board, hard-sized sulfite board, and gypsum. Five rows of burners (three above and two below), were mounted in a watercooled frame between the third and fourth press rolls. Heat was shot directly on the moving sheet. Controls were in accordance with insurance requirements. Actually, the use of only four burners were required

Fig. 12. Thermodot radiation thermometer Model TD-1

to provide a production increase of 4%. Enough moisture was removed by the first burner to provide a visible fog. When the sheet entered the drier, the moisture content had been reduced several per cent and the sheet temperature had been increased to such a degree that sticking on the first drier had been eliminated and the efficiency of the press roll had been increased. The fuel used in this installation was propane. The point is made here that the cost of the fuel can easily be justified by the results obtained.

A midwest company had a problem of insufficient drying capacity on the heavy stock they manufactured. An engineering survey showed that it was not economical to install new steam driers to obtain the 10% speed increase desired. New concrete foundations would have been required together with a new roof, in order to stack the driers. Another study disclosed that radiant burners could be installed with ease under the existing steam cans, which would increase the heat by radiation and convection. Six rows of burners, as shown in Fig. 8, 112 in. long, were installed with all required safety devices. Each 112-in. burner had an input of 784,000 B.t.u. for a combined capacity of 4,704,000 B.t.u. per hr. The result—a gain of 8% speed using five of the burners, with a capital investment of less than $10,000. The sixth burner was located on the second deck and probably has been reinstalled below the wet and drier by now. The fuel cost was less than $8.00 per ton of increased capacity.

A southern manufacturer of a specialized paper stock could not obtain production requirements on heavy materials. The installation of additional stacks of driers were physically and financially impractical, despite the fact that an increase of 50% in certain grades, was required. Eight rows of burners,

216 in. long, were installed with all necessary controls. Two of the rows were installed, one above and one below the paper, between the last press and the first stack. The balance of the burners were installed beneath the drier cans at a 5:00 o'clock position. The cost of this installation was just under $30,000. The actual increase in production was slightly over 50% but the cost per ton of extra production was difficult to obtain due to the fact that the automatic steam temperature devices modulated when all eight gas burners were operating. The need for the extra production dictated the necessity of the installation. Economics were not a

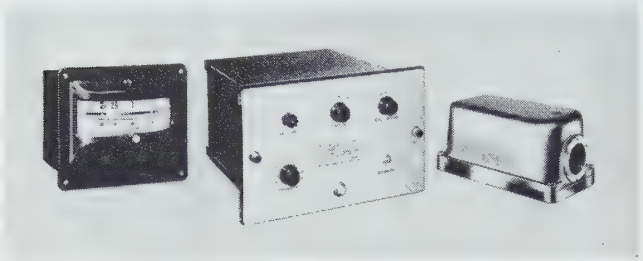


Fig. 13

factor but it was reported that the investment was amortized in less than 60 days, and the operating cost of $3.74 an hr., was considerably cheaper per ton of production than steam at 60¢ per thousand pounds.

It might be a good idea at this time, to digress and discuss some matters that are probably self evident to most of you. The processes that require heat in the production of paper, are principally drying and curing. Paper can be damaged, or even burned, and yet the temperatures must be sufficiently high to provide sufficient drying or curing at profitable speeds. How high these temperatures may be will vary with material and conditions. During the initial stages of drying, the percentage of moisture is high enough that excessive temperatures can be safely used. The rapid evaporation of the moisture creates a refrigeration effect that prevents the paper from reaching damaging temperatures. As the moisture content is reduced, the drying temperatures must be reduced accordingly. This is why it is possible and practical to use intensive quantities of radiant heat at the wet end of the drier.

Earlier it was pointed out that inputs of 2500 B.t.u. per lb. of water to be evaporated, were more or less standard and that this was true, no matter what the source of heat. The burners under discussion range variously from 3 in. in width to 8 in. and all can be manifolded to any desired lengths. Inputs vary from 1500 B.t.u. per lineal inch to 11,000 B.t.u. for straight radiant burners and up to 50,000 B.t.u. per lineal inch for combination radiant and convection types. To determine the type of burner to do a specific job, it is only necessary to bear in mind that every 1000 B.t.u. per lineal inch of burner; will remove from $4^1/_2$ to 7 oz. of water, depending upon whether the burner is under the paper facing upward or above the paper burning downward, wherein the convection heat is lost. Assume a 60-lb. stock being presently dried at the rate of 1100 f.p.m., and that this stock is 216 in. wide. This is an hourly production rate of 5.64 tons. Assume also that this represents a moisture removal of 26,000 lb. per hr. If an increase of production of 10% is desired, then an extra water removal of 2600 lb. per hr. must be obtained. This is roughly 10 lb. of water per lineal inch and burners designed with an input of 35,000 B.t.u. per lineal inch must be used. This could be five rows of burners with a capacity of 7000 B.t.u. per lineal inch or twenty rows of burners with a capacity of 1750 B.t.u. per lineal inch. This in itself, would be determined by physical limitations as to placement and the effect of intense heat on environmental structures, type of material and wet strength of material desired at any specific point.

The theory of infrared as stated by the untutored is that infrared energy dries from the inside out. From what has been said so far, relative to heat transfer, it is obvious that infrared energy is absorbed at the surface of the material and there convection takes over. Infrared is a drying medium with many other characteristics of other types of heat and when the surface is dried too fast, the same deficiencies in product will be noted. Too fast a drying rate at the wet end is almost impossible. The maximum efficiency therefore, can be obtained on wet end applications with secondary considerations given to drying after rewet and before calendering.

Radiant heat thus far, has been primarily discussed in its application to stock drying. Little mention has been made of some of the other purposes that radiant heat can effect in the paper industry. Figure 9 shows radiant burners used in ink drying on high speed magazine printing. Figure 10 shows an experimental coating machine used in the laboratory of a large paper manufacturer. The very nature of radiant energy enables it to be used for the drying of coatings, ink, and silicones. Figure 11 shows the actual drying of silicone on a paper web.

There is one field that is going to require considerably more study before much can be said about it, and that is the application of radiant heat to the pulp on the fourdrinier wire. The advantages of using radiant heat are apparent when the desirability of reducing the density of the water in the pulp before entering the presses is considered. Some factors involved in this study would involve a determination as to what heat the wire would be subjected to. When the water has a low pH, heat would increase the corrosive action on the wire. What the effect of the cold water shower on the heated screen would be, would also have a bearing on this subject. Could any possible detrimental effect be overcome by the use of hot water in the shower? Would the heat on the screen, if it exists to any degree, tend to anneal the wire and prolong its life? The meager results from tests using steam and radiant burners on different occasions showed

Fig. 14. Red-Ray burners mounted under first 11 driers on paper machine

that further study is warranted. The tests were not of sufficient magnitude to make any determination on wire life.

SUMMARY

In attempting to summarize all that has been said, it would be very nice if it could all be wrapped up in one little tight ball of yarn. Unfortunately, this can't be done. There are too many variables and too many unknowns.

Radiant heat will provide increased speeds with relatively small capital investments. This factor in itself, is sufficient

to warrant serious study as to what part it can play in any paper mill. There is no evidence that in the foreseeable future the steam drum can be eliminated, but there is definite evidence that the number of them can be considerably reduced. Speed is the watchword of present day industry and radiant heat can provide hitherto unheard of results.

Another very definite advantage of radiant heat lies in the fact that direction can be given to the heat, enabling applications at precise required points. Pattern heating can also be made practical, especially when the thickness of the web dictates the desirability of greater heat concentration in the center.

Reproducible results are based on precise temperature control. Radiant heat can be modulated almost to any desired degree. Instruments to measure the temperature of a moving web, without contact, are available. These instruments use the principal of infrared emission to measure the temperature with remarkable accuracy. Two of these are here for your inspection. Figure 13 shows the unit primarily designed for research and development. Its temperature range is from 100 to 8000°F., with a full scale response time of 200 milliseconds. The output of the unit can be transmitted to any existing control device such as a pyrometer, potentiometer, etc. Figure 12 shows a unit designed for industrial applications. It can be permanently mounted or used on a tripod. It is available in various temperature ranges and its output can be used in the same manner as any thermocouple for control purposes or temperature readout. The combination of precise temperature measuring devices and flexible radiant heat, open new horizons for the paper industry.

The instant response of radiant heat to demand should be mentioned at this time. The ability of a radiant burner to modulate from full off to full on, presents a method to help achieve the very desirable characteristic of uniform production. The fact that when the gas is cut off from the burner and the air continues through the burner itself aids in cooling the face of the burner, has already been mentioned, but it should be noted that this is a safety feature in addition to being advantageous for uniform processing. A partially dry web in contact with a hot can does not make the best appearance.

There are few mills, if any, where space is not at a premium. The compactness of radiant burners is a big plus when considering how to get increased production. Using as an example the fact that a burner 6 in. wide can remove 3 lb. of water per hour per lineal inch, presents a picture of how compact an installation can be. Figure 14 shows burners installed under the first 11 driers on a paper machine. Notice that no additional space was required and yet a production increase equal to the installation of 16 driers was achieved. Automation is a word that has recently acquired a new meaning due to the rising labor costs. There is no need to dwell on how readily radiant heat can be automated. Perhaps some mention should be made of labor savings resulting from reduced maintenance, reduced boiler room requirements, and of course, less labor per ton of product.

Infrared energy plays an important role in industry. Its techniques are not known nearly so well as those of convection and conduction. Its use has been found to be superior to other methods because: (1) it is faster because startup and stopping is instantaneous and there is no warm up period, (2) operation and consumption are simple and truly more economical, (3) it can be focused, reflected or polarized, (4) it is not affected by air currents, (5) proper design will produce a uniform radiant flux intensity where required.

Strangely enough, considerable study was made on the subject of infrared in the early 1900's. Interest then tapered off until the end of World War II at which time many manufacturers revived their interest in infrared burners.

Presented at the 15th Engineering Conference of the Technical Association of the Pulp and Paper Industry, held in Jacksonville, Fla., Oct. 24–28, 1960.

The Use of Ductile Iron in the Pulp and Paper Industry

E. G. HOLMBERG

The melting practice employed in the production of this relatively new development in the cast iron industry is briefly discussed. The structure of ductile iron and its mechanical properties are compared with other forms of iron. A rather detailed discussion is presented dealing with the effect of structure and the part played by electrochemical reactions in the corrosion of grey cast iron, ductile iron, and mild steel. Corrosion data are shown which compare the resistance of these materials to various pulp and paper mill environments. The conclusion is drawn that ductile iron is ideally suited for equipment and structures where the mechanical strength of mild steel and the corrosion resistance of cast iron are required. The application of ductile iron in various types of pulp and paper mill machinery are discussed. The strength and heat-treatable characteristics of ductile iron are attributed for its successful use in many of the applications.

Ductile iron is a cast iron in which the graphite particles are present in a spheroidal form. This type of cast iron has also been designated as nodular cast iron, spheroidal graphite iron, and S.G. iron. The addition and retention of a small percentage of magnesium in a ferrous melt having a composition essentially the same as that of gray iron will cause the graphite particles to assume a spheroidal form. When graphite is present in this form those mechanical properties of gray iron, which are impaired by a virtually continuous network of graphite flakes, are greatly improved. Annealed ductile iron will have mechanical properties that are comparable with those of ordinary grades of carbon steel.

There are a number of ductile iron grades, some of which have compositions adjusted to provide satisfactory performance under specific conditions. Most commercial castings, however, will fall within the following composition range:

Total carbon, %	3.0–4.0
Silicon, %	2.0–3.0
Manganese, %	0.2–1.0
Phosphorus, % max.	0.1
Sulfur, % max.	0.02
Nickel, %	0.0–3.0

The ASTM Specification A339-51T Nodular Iron Castings covers grades 80-60-03 and 70-45-10. These numbers when read consecutively denote minimum mechanical properties. For example, grade 80-60-03 has 80,000 p.s.i. minimum tensile strength, 60,000 p.s.i. minimum yield strength and 3% minimum elongation. Grade 80-60-03 has essentially a pearlitic structure with good machinability. It responds readily to flame or induction hardening. Grade 60-45-10 has a structure which is essentially ferrite. It is not as readily flame or induction hardened as Grade 80-60-03. This paper will be concerned for the most part with the application of these grades.

FOUNDRY PRACTICE

Ductile iron is made by retaining a small amount of magnesium in a ferrous metal melted in either a cupola, electric furnace, or air furnace. The metallic charge normally consists of structural steel, pig iron, and returns which are all of known chemistry. The addition of magnesium is accomplished by plunging either metallic magnesium or a magnesium alloy into the molten metal while retained in a ladle after tapping from the melting unit. Another procedure is to place the magnesium alloy at the bottom of the receiving

E. G. Holmberg, The International Nickel Co., Inc., New York, N. Y.

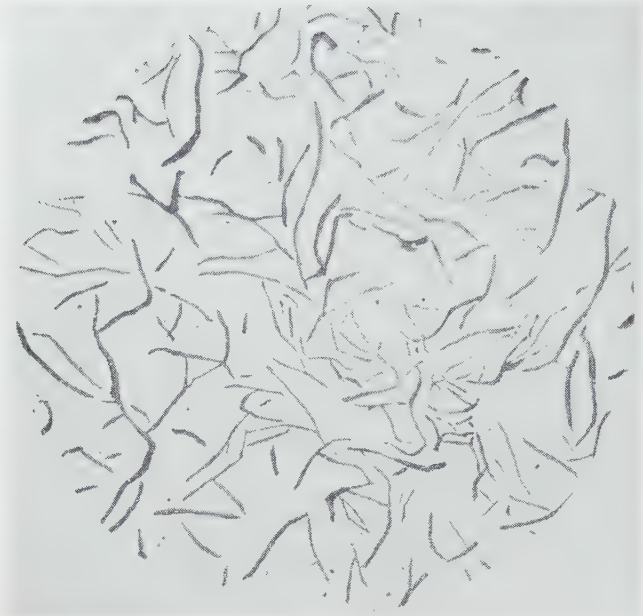


Fig. 1. Photomicrograph of flake graphite structure in gray cast iron. Original magnification 250×

ladle and allow the molten metal to pour over it when the melting unit is tapped. Castings are usually poured when the metal temperature in the ladle is between 2600 and 2750°F.

Careful metallurgical control control is required to produce satisfactory ductile iron castings. The raw materials must be selected carefully to avoid contamination with minor amounts of some elements which will have an inhibiting effect on the formation of spheroidal graphite structure.

Some ductile iron castings are used as cast and some are heat treated. The annealing treatment to produce ferritic ductile iron castings consists of: (1) heating to 1600 to 1650°F. to decompose any metastable carbides, if any are present, (2) cooling at a slow rate to 1275 to 1325°F. and then holding at this temperature to decompose pearlite, if any is present, (3) cooling in any convenient manner to room temperature.

MICROSTRUCTURE

Ductile iron combines the processing advantages of cast iron; i.e., low melting point, good fluidity, and castability with many of the engineering advantages of steel which include high strength, toughness, ductility, and hardenability.

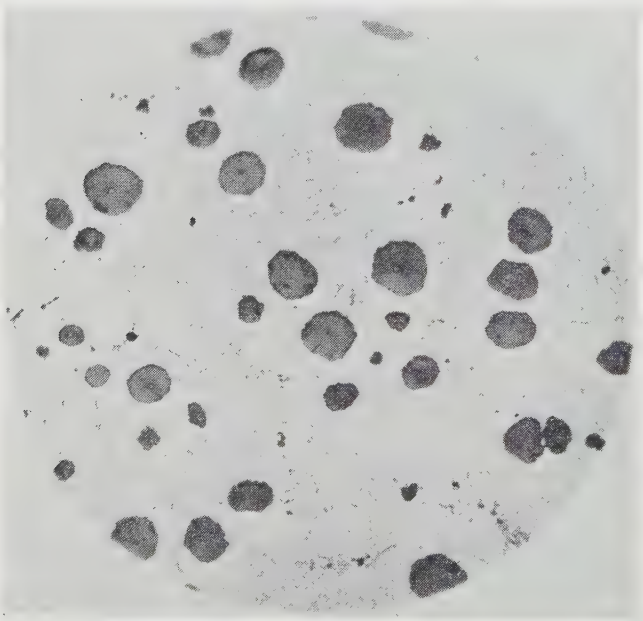


Fig. 2. Photomicrograph of spheroidal graphite structure in ductile iron. Original magnification 250×

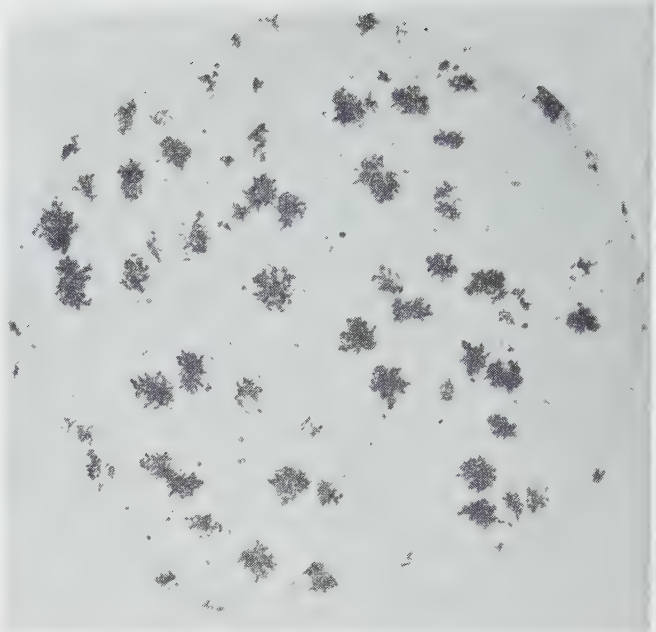


Fig. 3. Photomicrograph of nodular graphite structure in malleable iron. Original magnification 250×

The chief factor which limits strength and makes ductility virtually nonexistent in gray cast iron is the presence of random graphite flakes as shown in Fig. 1. These flakes break up the continuity of the metal matrix and setup, in effect, a whole series of notches which act as stress concentrators causing relative brittleness and low strength. The spheroidal shape of graphite in ductile iron, as shown in Fig. 2, removes the embrittling and weakening effect of flake graphite. Graphite in the spheroidal shape has the least surface to volume ratio and, therefore, has the least effect on the properties of the metal. It is this unique structure of ductile iron that imparts to it properties more like steel than cast iron.

Figure 3 shows the microstructure of malleable iron. It will be observed that this structure is quite similar to ductile iron. Graphite in malleable iron takes the shape of nodules while in ductile iron it has the shape of spheroids. In both metals the matrix structure will vary from soft, ductile, machinable in the ferritic types illustrated, to harder, stronger, and less machinable when the structure is pearlitic. The pearlitic microstructure of ductile iron is shown in Fig. 4.

Fig. 4. Photomicrograph of pearlitic ductile iron structure. Original magnification 250×

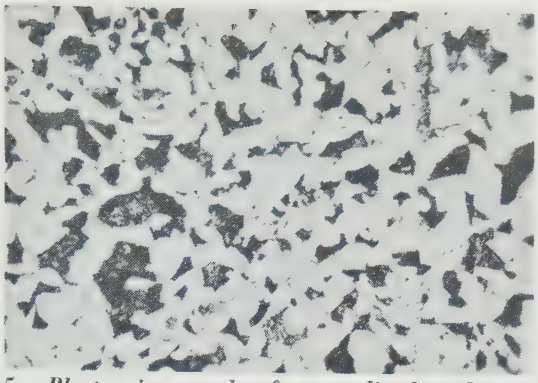


Fig. 5. Photomicrograph of normalized and tempered 0.30 C grade B cast steel. Original magnification 590×

These structure variations will depend upon chemical composition, section size and heat treatment. Ductile iron can be made in a wider range of section sizes than malleable iron. It has higher strength for a given ductility. The smoother graphite particles in ductile iron than in malleable iron are a contributing factor to its better physical properties. Much larger castings are possible in ductile iron and usually it is less costly than malleable iron because of lower heat treatment and handling costs.

Figure 5 shows the microstructure of cast steel. In cast steel carbon is in a combined form and usually exists as pearlite while in ductile iron a large portion of the carbon exists as spheroidal graphite. The differences in the amount of carbon present and the form in which it occurs are responsible for the differences in physical properties, wear and corrosion resistance of ductile iron and cast steel.

MECHANICAL PROPERTIES

A comparison of the tensile strength, yield strength, and elongation of ductile iron with that of other materials is shown in Figs. 6, 7, and 8. It will be observed that for an equivalent tensile strength ductile iron has an elongation somewhat below that of cast steel. However, for an equivalent tensile strength ductile iron will have a higher yield strength than cast steel.

The properties of the different types of ductile iron are dependent upon the structure of the steellike matrix which surrounds the graphite spheroids.

A definite relationship exists between tensile strength, elongation and hardness of ductile iron. The ratio of tensile strength to Brinell hardness is approximately 420 to 1 for types 60–45–15 and 80–60–03. This relationship is useful as a simple hardness measurement on a casting will give a reasonable indication of mechanical properties, provided the casting is sound and free of primary carbide. Castings having sections less than $1/4$ in. thick are likely to contain primary carbide in the as-cast condition. These castings must be heat-treated to eliminate the carbides before the hardness-mechanical properties relationship will respond.

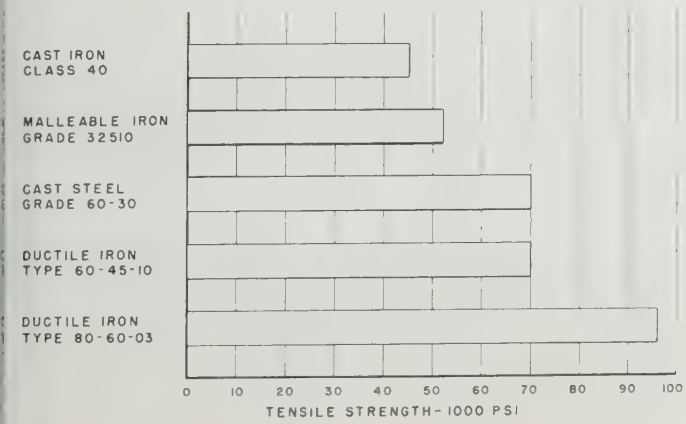

CAST IRON CLASS 40
MALLEABLE IRON GRADE 32510
CAST STEEL GRADE 60-30
DUCTILE IRON TYPE 60-45-10
DUCTILE IRON TYPE 80-60-03
0 10 20 30 40 50 60 70 80 90 100
TENSILE STRENGTH-1000 PSI

Fig. 6. Ductile iron has a tensile strength equivalent to cast steel

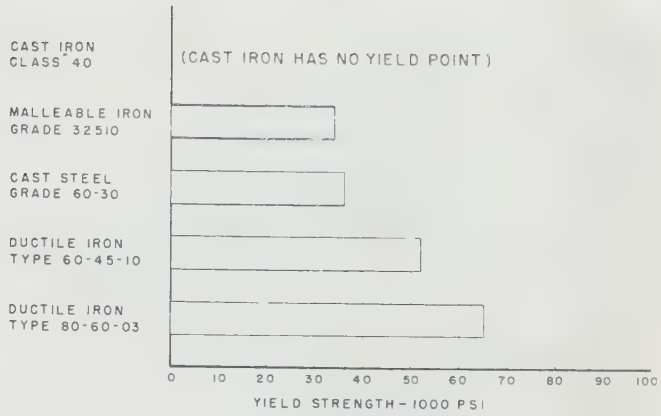

CAST IRON CLASS 40
(CAST IRON HAS NO YIELD POINT)
MALLEABLE IRON GRADE 32510
CAST STEEL GRADE 60-30
DUCTILE IRON TYPE 60-45-10
DUCTILE IRON TYPE 80-60-03
0 10 20 30 40 50 60 70 80 90 100
YIELD STRENGTH-1000 PSI

Fig. 7. Ductile iron has a yield strength greater than cast steel of equivalent tensile strength

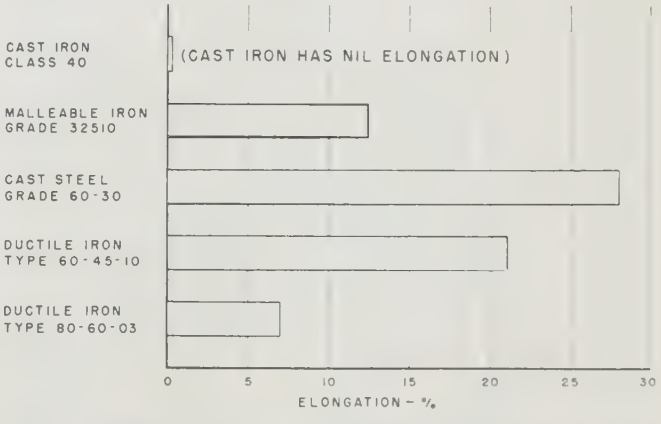
MACHINABILITY

The machinability of ductile iron is superior to that of other ferrous metals. The machinability rating of ductile iron compared with that of other materials is shown in Fig. 9. The machinability of ductile iron will increase with increasing amounts of graphite in the structure and decrease with increasing mechanical properties. The ferritic type 60–45–15, therefore, will have better machinability than the semipearlitic type 80–60–03.

WELDABILITY

Ductile iron can be welded to itself and other materials successfully by the metallic arc, gas welding, or induction pressure methods. The metallic arc method is best suited for the ferritic grade 60-45–15. The best all-around electrode for minimum preheat and crack-free welds is the coated austenitic nickel-iron type, marketed under the trade name of Ni-Rod 55. Mild steel low hydrogen electrodes (types E6015-16) are also successfully used, particularly for joining to carbon steel. Oxyacetylene is commonly used for repairs with such rods as the Linde Ox-weld no. 69. All of these methods will require postweld annealing treatment to restore the base metal elongation.

Because of fast cooling after welding the heat affected zone adjacent to the weld deposit will undergo a metallurgical change. This zone which will be approximately $1/16$ in. wide on either side of the weld will contain some carbon in the form of cementite or iron carbides. If annealing of the casting after welding is practical, the ductile graphite ferrite structure can be restored. In the event annealing after welding would be impractical, the weld area, although less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(CAST IRON HAS NIL ELONGATION)
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CAST STEEL GRADE 60-30
DUCTILE IRON TYPE 60-45-10
DUCTILE IRON TYPE 80-60-03
0 5 10 15 20 25 30
ELONGATION-%

Fig. 8. Ductile iron has an elongation slightly less than cast steel of equivalent tensile strength

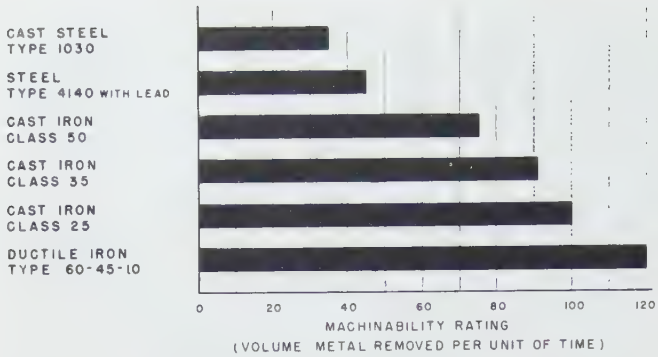

Fig. 9. Ductile iron has better machinability than cast iron of equal hardness and also steel of equivalent strength

ductile than the parent metal, will still retain resistance to shock loads.

WEAR RESISTANCE

Wear resistance is one of the outstanding properties of ductile iron. Service performance data on such items as cylinder liners, crankshafts, metal working rolls, dies, and gears have shown that the wear resistance is equivalent to that of the best grades of gray iron. The spheroidal graphite particles serve as reservoirs to store lubricant for starting-up periods and to prevent galling and scuffing during short periods of positive lubrication failure. There are a number of applications where ductile iron has proved to be markedly superior to gray iron. These usually involve impact loads or heavy loads that cause pitting of gray iron, such as in some gear applications. Ductile iron has a good resistance to this type failure.

HEAT RESISTANCE

Ductile iron is ideally suited for components in equipment such as sulfur burning furnaces because of its excellent resistance to oxidation and growth. The flake graphite of gray iron provides avenues of entrance into the structure which results in rapid oxidation of the iron adjacent to the flakes. The spheroidal graphite structure of ductile iron does not form the semicontinuous paths offered by graphite flakes and is, therefore, not conducive to penetration by oxidizing gases. The depth of oxide penetration of ductile iron compared with other materials after testing at 1300°F. for 2000 hr. is shown in Fig. 10.

The subsurface oxidation of gray iron at elevated temperatures is largely responsible for its greater susceptibility to growth than ductile iron. The rapid oxidation of the iron adjacent to the flakes results in a volumetric expansion

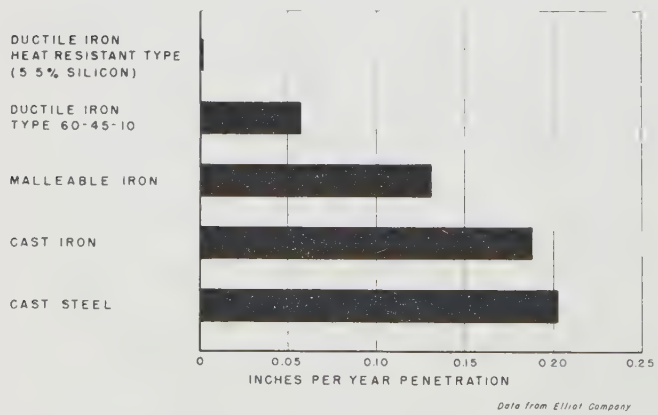

Fig. 10. Depth of oxide penetration for various materials. Tested at 1300°F. for 2000 hr.

Table I. Growth of Gray Iron and Ductile Iron After 6696 hr. at 1000°F.

	Growth, %
Gray iron	0.54
Ductile iron (grade 80-60-03)[a]	0.24
Ductile iron (grade 60-45-10)	0.027

[a] Stress relieved.

caused by the oxide product formed. Dimensional increases can also be caused by a change in metallurgical structure. One such metallurgical change that can occur at elevated temperatures is graphitization of the carbide component in pearlitic irons. If, however, the matrix is predominantly ferritic initially, then this factor cannot significantly operate to promote growth. Ductile iron containing pearlite is not exempt from this type of growth as is apparent from the data presented in Table I which compares the growth of several irons after nearly 7000 hr. exposure at 1000°F. Here, while both ductile irons were better than flake graphite irons, the ferritic (grade 60-45-15) ductile iron shows an advantage of nearly 10 to 1 over the pearlitic (grade 80-60-03) ductile iron. Since oxidation does not proceed as rapidly at this low temperature, graphitization is the dominant factor in the relative growth of the two ductile irons. It will be observed that in this long time growth test, grade 60-45-15 ductile iron shows 20-1 advantage over gray iron while grade 80-60-03 ductile iron shows slightly better than 2 to 1 advantage.

CORROSION RESISTANCE

The principal advantage that ductile iron will have over gray iron is its decidedly superior mechanical properties. In general, ductile iron will have a corrosion resistance to most environments which is equivalent to that of gray iron. Therefore, when it is desired to take advantage of (1) the better corrosion resistance of cast iron to a particular environment, and (2) the mechanical strength of steel, ductile iron becomes the ideal choice.

In Table II corrosion rates are tabulated which show the resistance of ductile iron, gray iron, and carbon steel to a number of paper mill environments.

Although it has been stated that ductile iron has a corrosion resistance to most environments which is equivalent to that of gray iron, under some conditions graphite distribution becomes important (*1*). The form and distribution of graphite in ductile iron can be expected to favor its having a better corrosion resistance than gray iron under some exposures. As in the case of oxidation, the paths provided by the flake graphite network (*2*) in gray iron will permit corrosion to penetrate to a greater depth and thus expose a

Fig. 11. Ductile iron pipe for underground service

greater area of the matrix to attack than is possible with ductile iron. Since graphite in all grades of cast iron is cathodic to the iron matrix, corrosion will be accelerated galvanically in most environments. The intensity of this effect upon initial exposure should be greater in the case of gray iron than ductile iron because of the greater amount of exposed graphite. This initial effect, however, may have little bearing on ultimate service life as the controlling factor will be the type of corrosion product finally formed.

Graphite will not be soluble in most environments to which cast iron has a suitable resistance. Therefore, when the iron matrix is corroded away the graphite which is left behind will form a uniform coating over the metal surface. This condition is commonly referred to as graphitization. When not exposed to severe velocity conditions these graphite coatings will adhere rather firmly to the underlying metal. The firmness of the attachment and degree of permeability of this graphitic residue will be dependent upon the nature of the corrosion products with which it becomes intermixed. Silicious compounds, phosphide eutectic stringers, carbides, and insoluble corrosion products precipitated within the graphite layer can all contribute to a high degree of impermeability. These coatings can become so impermeable to further penetration of the corrosive liquid as to provide complete protection of the underlying metal. This effect may be responsible for the better corrosion resistance reported for ductile iron in test 1, Table II. Under these conditions carbon steel was not able to form as protective a coating as ductile iron.

Table II. Comparative Corrosion Data For Ductile Iron, Gray Iron, and Carbon Steel to Various Paper Mill Environments

Test no.	*Environment*	*Corrosion rate, in. penetration per yr.* — *Temp., °F*	*Ductile iron*	*Gray iron*	*Carbon steel*
1	Black liquor from semi-chemical pulping of aspenwood; 9.2% sodium sulfite, 3% sodium carbonate, pH 6.8 to 7.3	160	0.066	...	0.13
2	Mill waste water	100	0.039	0.060	...
3	Kraft and neutral sulfite pulp stock; 0.049 g.p.l. H_2SO_4, 0.068 g.p.l. sulfate, 0.038 g.p.l. sulfide, pH 6.0	100	0.0052	0.0048	0.0064
4	Flue gases from sulfate recovery furnace	310	0.0032	0.0026	0.010
5	Groundwood pulp; 0.8% consistency, pH 5.0	125	0.026	0.030	0.023
6	Kraft and semichemical white water; pH 6 to 8	85	0.006	0.004	0.0072
7	Kraft white water; pH 7.2 to 8.2, 0.025 g.p.l. sulfide, 0.045 g.p.l. sulfate, 102 p.p.m. chlorides	85	0.006	0.005	0.006
8	Kraft pulp stock; 0.015 g.p.l. H_2SO_4, 0.045 g.p.l. sulfate, 0.025 g.p.l sulfide, pH 6.9	100	0.006	0.006	0.005
9	Kraft and neutral sulfite pulp stock; 0.049 g p.l. H_2SO_4, 0 068 g.p.l. sulfate, 0.038 sulfide, pH 6	100	0.005	0.005	0.006
10	Mill water; 1200–1700 p.p.m. sodium chloride, 1000 p.p.m. calcium chloride, 250 p.p.m. calcium sulfate, 85 p.p.m. magnesium chloride, pH 7.5 to 8.4	135	0.017	0.020	...
11	18% sulfur dioxide plus small amount sulfur trioxide, plus moisture, plus 3% oxygen	600	0.0014	0.0013	0.0010
12	Mill waste water from alkaline pulp bleaching	100	0.039	0.060	...
13	Chlorine filtrate (containing HCl), black liquor line sludge; pH 2 to 12	82	0.110	0.080	0.051

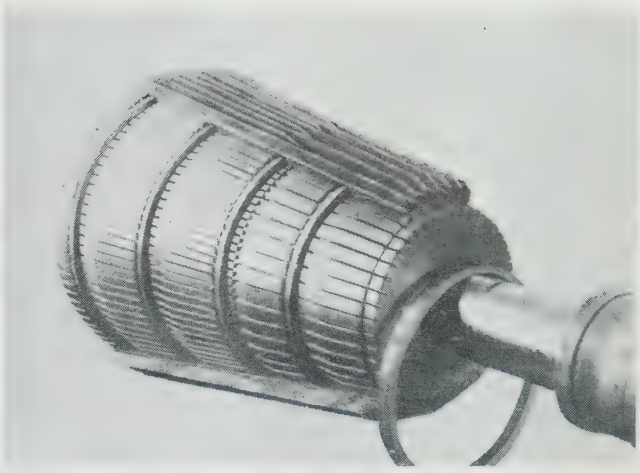

Fig. 12. Jordan plug body of ductile iron

Under conditions where the graphitic coating remains permeable, corrosion of the underlying metal will continue and probably at an accelerated rate because of the galvanic effect of graphite layer. Under these conditions cast iron corrode at a higher rate than steel. When the corrosion products formed are not sufficiently insoluble to result in the formation of an impermeable graphite coating, exposure to velocities of sufficient magnitude to keep freshly formed graphite removed from the surface may have the effect of improving corrosion resistance.

When the graphite corrosion product layer does not become impermeable corrosion can proceed until none of the original cast iron remains. This completely converted graphitic material will retain the original shape and dimensions to such a high degree, that upon casual inspection there would appear to be no serious damage. Since the graphitic corrosion products are much weaker than the original cast iron mechanical properties have been seriously impaired.

Once either gray cast iron or ductile cast iron acquires a layer of graphite corrosion product complex galvanic relationships can develop. The graphite layer will exhibit a potential several hundred millivolts more noble than ungraphitized cast iron or steel (*3*). This will make it cathodic to the underlying iron, to associated mild steel and to virtually all other commercial alloys with which it may be associated in the

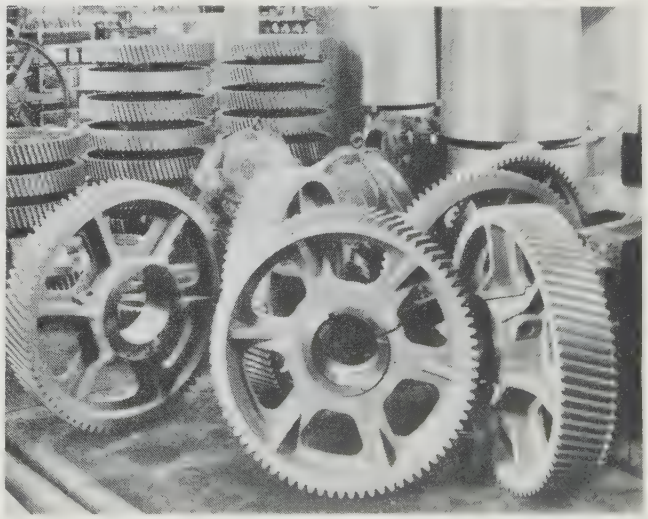

Fig. 13. Ductile iron paper machine gears

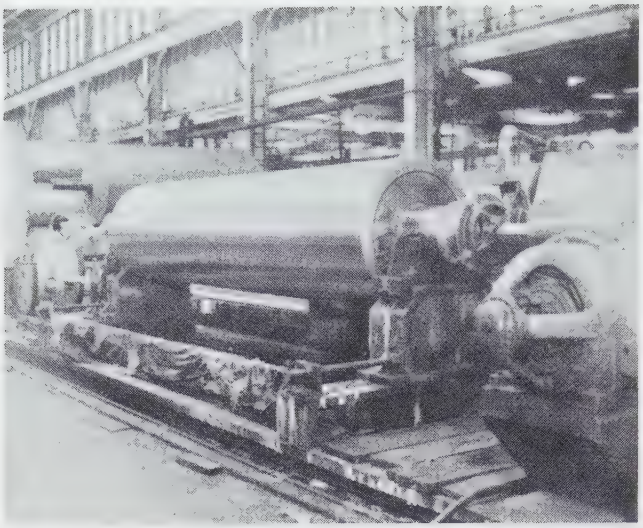

Fig. 14. Ductile iron crownless press roll

normal construction of equipment. When the graphite coating is permeable and in contact with mild steel or other metals less noble than the coating, the galvanic effect will be shared by the underlying iron and the associated metal. Under these conditions the normal corrosion rate of ductile iron and gray cast iron will be substantially reduced. However, when the graphite coating is impermeable and the underlying iron no longer shares the cathodic action of the graphite coating with the associated less noble metal, attack of the associated metal will be intensified.

The formation of a graphite coating on cast iron or ductile iron can be substantially reduced by alloying with more noble elements such as nickel and copper that can be held in solution. The somewhat highly alloyed cast irons containing in the order of 20% nickel have a good resistance to the formation of graphitic coatings in most solutions for which they are suitable.

Although ductile iron and cast iron may show a fair resistance to some slightly acid solutions there is little opportunity for practical application of cast irons in strong acid solutions. By far the greatest use of cast iron is in neutral or alkaline environments.

Substantial differences can be observed in the behavior of different irons when exposed to neutral or alkaline solutions at velocities which will interfere with the adherence of corrosion products. Tests conducted at our Harbor Island Testing Station showed as-cast specimens of ductile iron with a pearlitic matrix to resist the velocity effects of sea water at 27 f.p.s. much better than ductile iron annealed to achieve a ferritic matrix. As described by Manuel (*4*), this difference

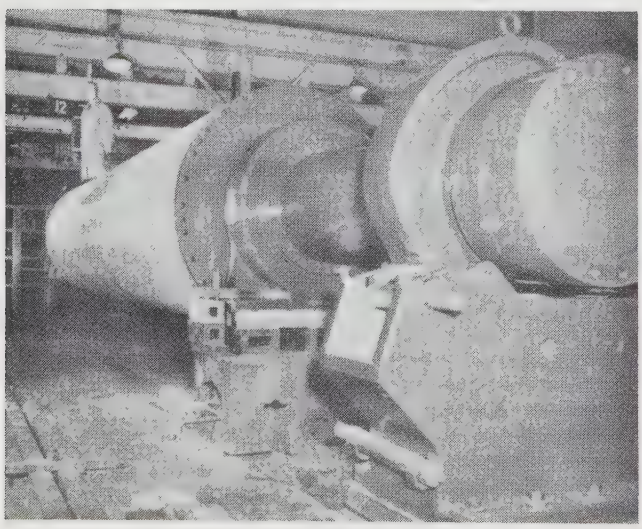

Fig. 15. Ductile iron cantilever head on suction roll

in behavior may be a result of better corrosion product adherence because of the teethlike residual pearlitic carbide particles that may be left on the surface of lamellar pearlitic iron. A microscopic examination of the pearlitic ductile iron specimen after this test revealed that it retained an adherent layer of graphitic corrosion product which had shielded the underlying metal from further attack. No such adherent corrosion product was found on the surface of the ferritic specimen.

In light of the foregoing, ductile iron with a pearlitic matrix should be selected when erosion is involved, so advantage can be taken of the protection offered by adherent graphitic corrosion products.

APPLICATIONS

Because of the long record of successful use of cast iron underground, there has been no hesitancy in adopting of ductile iron in such environments. In fact, ductile iron has become preferred to cast iron for these installations because it is practically immune to the breakage experienced when handling cast iron pipe. The photograph, Fig. 11, shows a quantity of ductile iron pipe destined for service as underground gas lines.

An ideal application for ductile iron is the jordan plug shown in Fig. 12. In this equipment ductile iron has a decided advantage over cast steel in that it has better machinability and galling is eliminated when the alloy blades must be removed for replacement.

Ductile iron gears have been used extensively as a replacement for both cast iron and steel gears. In practically all applications ductile iron gears have shown decidedly better performance than materials previously used. The photograph in Fig. 13 shows a group of paper mill drive gears in ductile iron type 80-60-03.

By employing ingenious design features and utilizing the mechanical properties to be offered by ductile iron, one manufacturer is now producing a crownless press roll. The photograph in Fig. 14 shows a ductile iron crownless press that is being used on a 150-ton machine designed to produce folding boxboard. When these rolls are made of gray cast iron they must be crowned as its low measure of stiffness will not permit maintaining a flat surface when the roll is under load. Ductile iron's high modulus of elasticity reduces deflection and thus eliminates the costly crowning operation.

The ductile iron cantalever head shown between the bearing supports in the photograph, Fig. 15, supports a 31 ton, 24 ft. long paper mill suction roll horizontally during changing of the screen. Ductile iron was selected for this application because it deflects less than steel and recovers quicker and more completely than steel.

This paper is being presented in response to a request for information on the properties of ductile iron as compared with gray cast iron and steel and also where it has application in the pulp and paper industry. An effort has been made in this presentation to cite only a few of the more outstanding applications of ductile iron in the industry. Other applications such as pumps, valves, compressor cylinder liners, machinery frames, etc., should not be overlooked.

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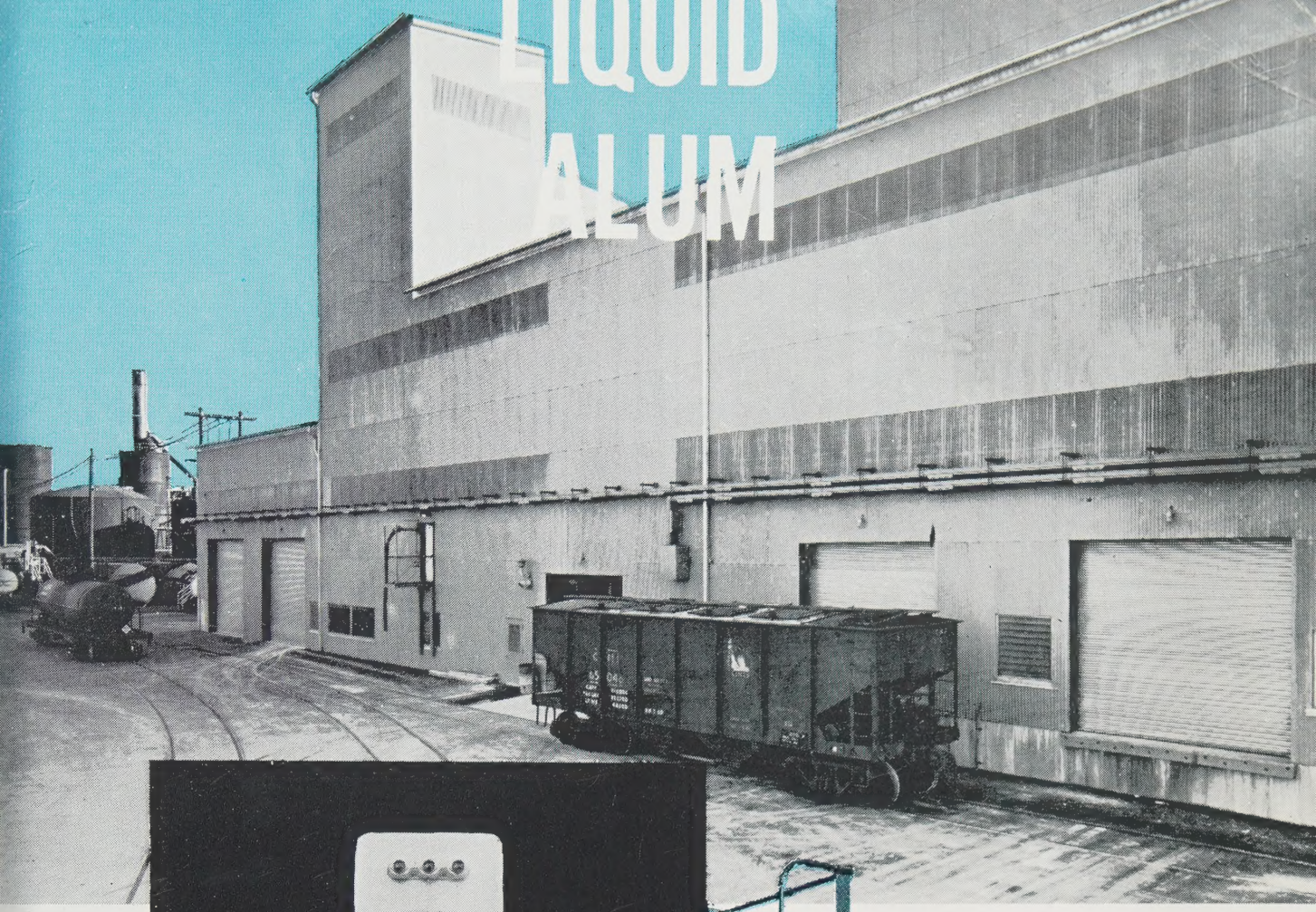

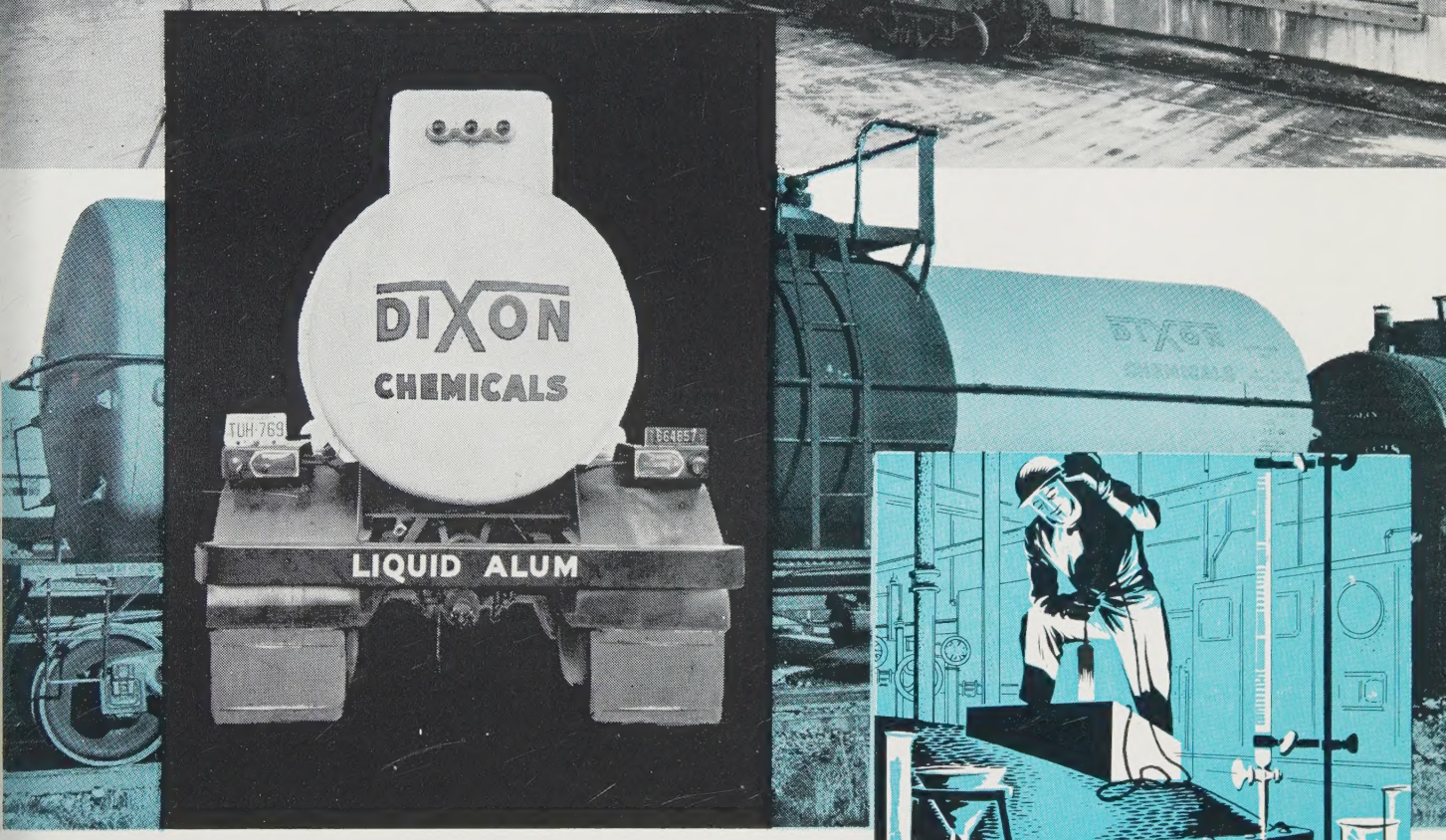

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